Appendix-9 Highway Engineering

9.1 INTRODUCTION

In this Appendix, the objective and positioning of the Project as a link in the highway network of Bangladesh are definitely defined firstly, and subsequently requirements for the Project highway which includes a major bridge across the Padma River and approach roads on both banks are clarified.

Then characters and functions of the four alternative locations of the Project in the context of highway planning are reviewed, and also characters of the bridge and approach roads at each location are discussed and comprehensively evaluated. Prioritization of alternative Project locations from the same aspects is also provided.

The preparatory study and analysis from the highway planning aspect on the two alternative Project locations selected through the comprehensive screening of the initial four ones are reported.

Finally, the policy, conditions and outcomes as to the highway planning and preliminary design of the approach road of the Project at the finally selected Mawa-Janjira location are presented.

9.2 OBJECTIVES OF PADMA PROJECT FROM HIGHWAY PLANNING ASPECT

Mighty rivers such as the Ganges, Jamuna, Padma and Meghna Rivers have historically divided the territory of Bangladesh, which administratively consists of six Divisions including Dhaka, Chittagong, Sylhet, Rajshahi, Barisal and Khulna, into four principal parts, viz the North Central(Dhaka Division), East(Chittagong and Sylhet Divisions), Northwest(Rajahahi Division) and Southwest(Khulna and Barisal Divisions) Regions.

The highway network in Bangladesh has been developed primarily aiming at linking the North Central Region where the capital, Dhaka, is located to other Regions. Presently, as inter-regional links across the mighty rivers, there are five major bridges in operation, viz Jamuna, Meghna, Meghna-Gumti, Bhairab, and Paksey Bridges. However, there is still no bridge of any transportation over the Padma River which separates the Southwest Region from the North Central Region. The social and economic development of the Southwest Region has been considerably hampered due to lack of reliable linkage of transportation to the North Central Region.

If a bridge to cross the Padma River is once constructed, it will certainly strengthen the linkage between the Southwest and North Central Regions. A highway bridge, particularly, will improve and enhance the freight and passenger transportation between Dhaka and major points in the Southwest Region and contribute remarkably to the regional development of the Southwest Region as well as the national growth of economy. Thus, the primary objective of the Project could be stated as the integration of the Southwest and North Central Regions through direct linking of highway networks in both Regions.

Moreover, the Asian Highway Route A-1 which was adopted by the United Nations Economic and Social Commission for Asia and the Pacific (UN ESCAP) to connect major cities in the southeast, south, central and west Asian countries in east-west direction is supposed to link Myanmar, India and Bangladesh and passes through Dhaka, Mawa and Bhanga in the area near the Padma River. This section of the National Highway N8 is being improved/rehabilitated as a part of the Southwest Road Network Development Project by the Government of Bangladesh with the assistance of the Asian Development Bank. If the Padma Bridge Project selects the Mawa site as its Padma crossing location, it will complement the missing link of the Asian Highway Route A-1 as well as the National Highway N8.

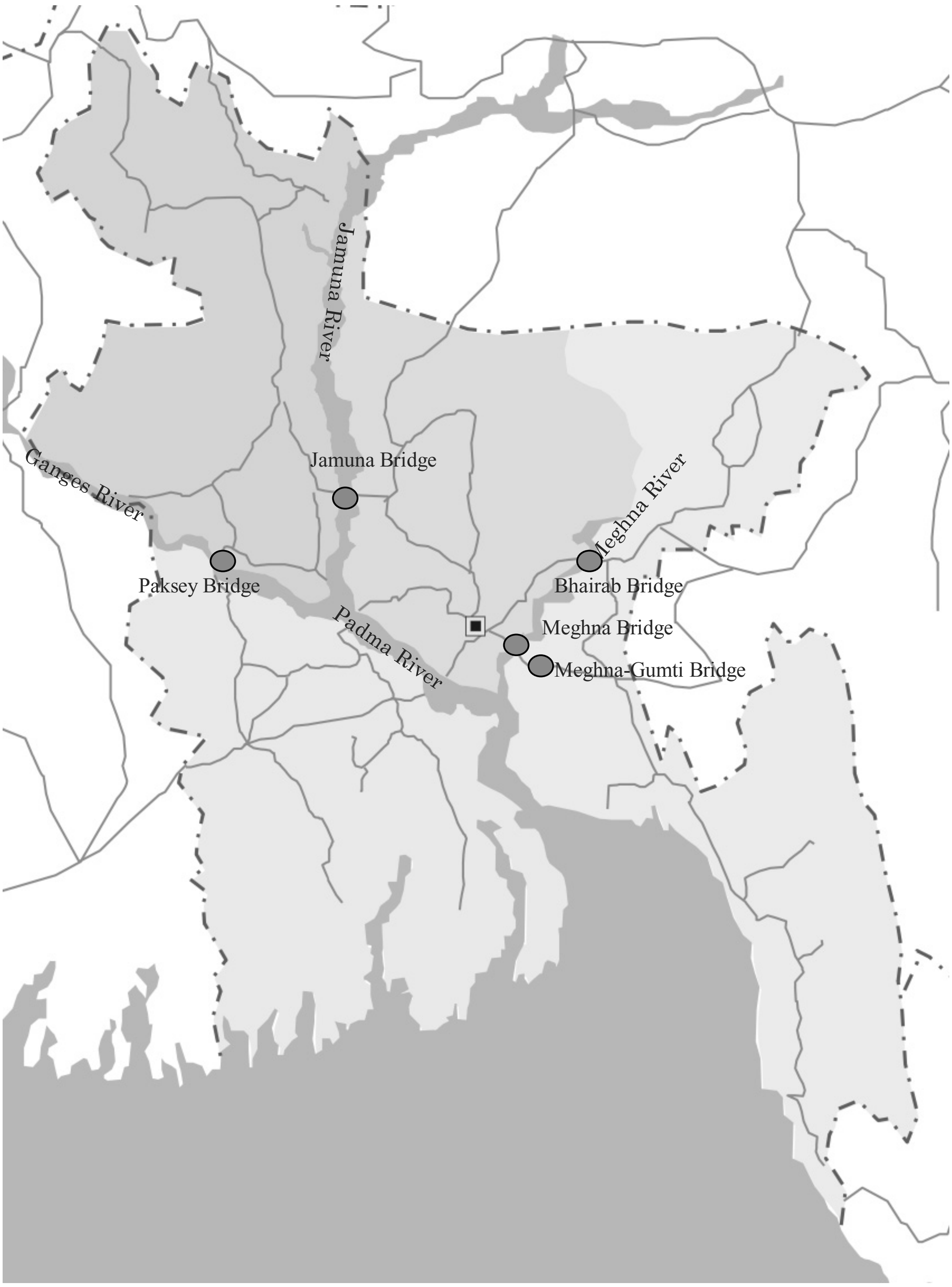


Figure 9.2.1 Four Regions of Bangladesh and Inter-Regional Bridges

9.3 ROAD SYSTEM OF BANGLADESH AND FUNCTIONAL REQUIREMENT FOR PROJECT HIGHWAY

(1) Road System of Bangladesh

The surface transportation of Bangladesh comprises the road, railway and inland waterway. Among them the road transportation has been getting steadily dominant. In 1996/97 the shares of the road in domestic freight and passenger movement were 63 % of total ton-kilometers and 73 % of total passenger-kilometers, respectively.

Presently the total length of roads in Bangladesh is over 220,000 kilometers. According to the reclassification approved by the Planning Commission in April 2003, they are classified into seven categories. The responsibility of construction, development and maintenance of those roads have been entrusted to three kinds of governmental institutions, viz RHD (Road and Highway Department, Ministry of Communications), LGED (Local Government Engineering Department, Ministry of Local Government, Local Development and Co-operatives) in collaboration with LGI (Local Government Institutions), and City Corporations/Pourashavas. The definition, ownership and responsibilities of the total road network are as shown in Table 9.3.1.

Among the seven road classes, the important nationwide passenger and freight transportation is born by arterial highways under RHD, such as the National Highways and Regional Highways, with higher hierarchical positions of the road system of Bangladesh. The arterial highway network covers the whole area of the country as shown in Figure 9.3.1.

(2) Functional Requirement for Project Highway

As defined in Table 9.3.1, the National Highways are highways connecting the national capital, Dhaka, with the Divisional headquarters, or sea/land ports, or the Asian Highway, while the Regional Highways are those connecting the District headquarters or main river/land ports with each other not connected by the National Highways. Considering its primary objectives such as described in 9.2 above, the Study Team judges that the Project highway across the Padma River is functionally required to be connected at both ends desirably to a National Highway, or at least to a Regional Highway.

Table 9.3.1 Road System of Bangladesh

DOMAIN	CLASSIFICATION	PRIMARY CONNECTION	LENGTH (km)	
RHD	National Highways	National capital to Divisional headquarters, Sea/Land ports and Asian Highways	3,086	20,799
	Regional Highways	between District headquarters, Main river/land ports, not connected by National Highways	1,751	
	Zila Roads	District headquarters to Upazila headquarters, or between Upazila headquarters, by a single main connection with National/Regional Highway, through shortest distance/route	15,962	
LGED in collaboration with Local Government Institutions(LGI)	Upazila Roads	Upazila headquarters to Growth Center(s), or between Growth Centers by a single main connection, or Growth Center to Higher Road System(National Highways, Regional Highways and Zila Roads), through shortest distance/route	23,434	201,738
	Union Roads	Union headquarters to Upazila headquarters, Growth Centers or Local markets, or	68,624	
	Village Roads	Villages to Union headquarters, Local markets, Farms and Ghats, or between Villages, and within a Village	114,126	
Municipal bodies like City Corporations and Pourashavas	Municipal Roads	within Urban areas	4,300 as of 1997	

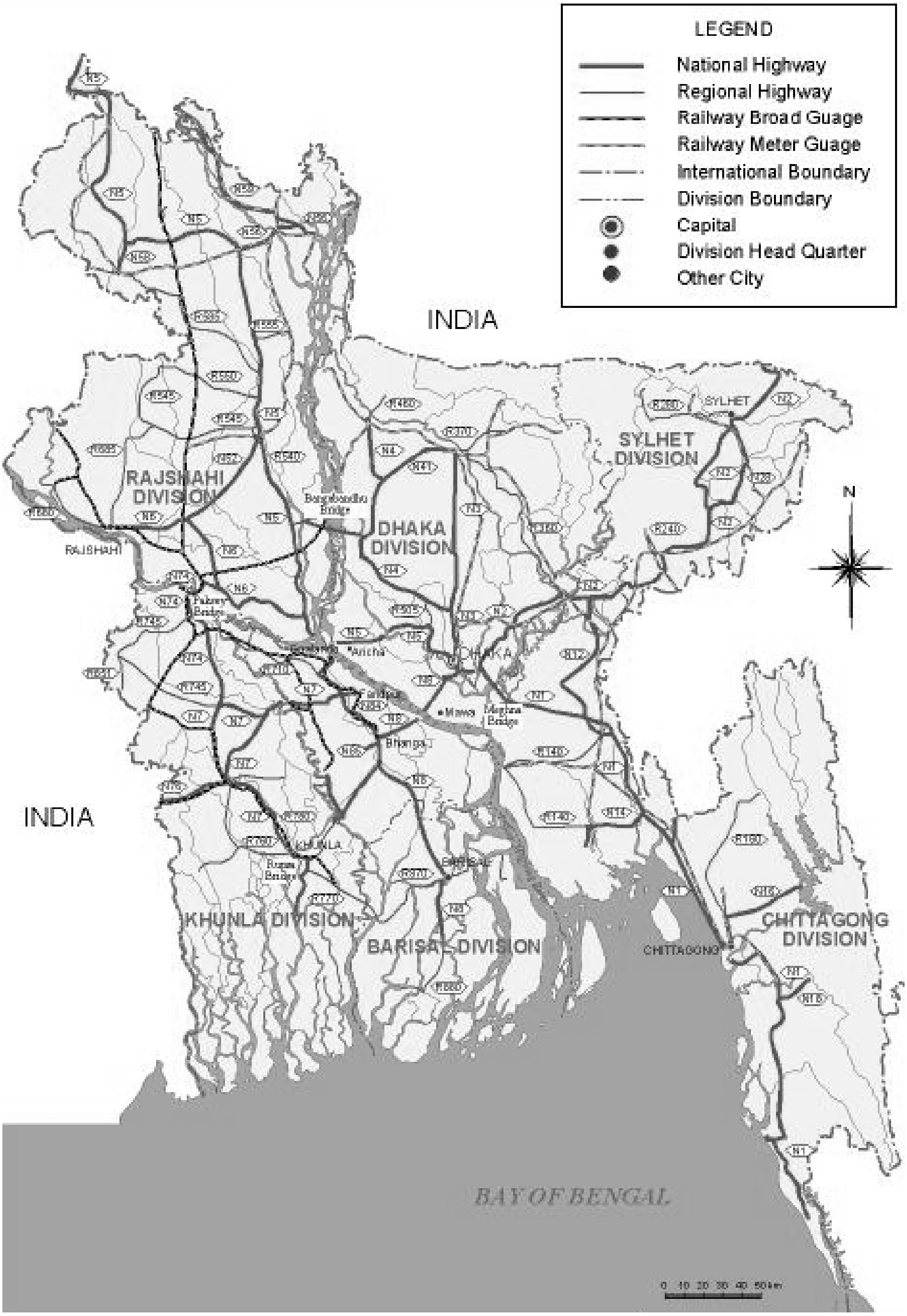


Figure 9.3.1 Highway Network in Bangladesh

(3) RHD Geometric Design Standards

According to the RHD Geometric Design Standards, there are six standard Design Types, as shown in Table 9.3.2, each of which is suitable for a specific range of traffic volumes for the design year, normally the tenth year after the road is open to traffic. Those Design Types correspond to the design speeds by terrain type, which subsequently relate to the horizontal and vertical curves and the sight distances, as shown in Table 9.3.3 and Table 9.3.4.

It should be noted that the design traffic volume in Table 9.3.2 is broadly set to a poor traffic condition (Level of Service "E" in the US Highway Capacity Manual), reflecting the scarcity of available resources for road improvement in Bangladesh. Also the highest permissible design speed is required to be 80 km/h, despite 100 km/h specified as the maximum in the Standards, reflecting the nature of traffic composing a large amount of slow-moving vehicles and pedestrians and the general lack of road user disciplines in Bangladesh.

Table 9.3.2 RHD Road Design Types

Design Type	Design Year Traffic Volume PCU/peak hour (Typical MV AADT)	Cross Section width in meters			Indicative Road Classification
		Crest Width	Carriageway (no. of lanes)	Paved Shoulders	
1	4,500 – 8,500 (19,000 – 36,000)	36.2	2 x 11 (6)	1.8	
2	2,100 – 4,500 (7,000 – 19,000)	21.6	2 x 7.3 (4)	1.8	National
3	1,600 – 2,100 (5,000 – 7,000)	16.3	7.3 (2)	1.5	Regional
4	800 – 1,600 (1,000 – 5,000)	12.1	6.2 (2)	1.5	
5	400 – 800 (500 – 1,000)	9.8	5.5 (2)	1.2	Zila Road
6	<400 (<500)	9.8	3.7 (1)	1.2	

Table 9.3.3 Typical Design Speeds

Design Type	Design Speed (km/h)		
	Plain	Rolling	Hilly
1 – 2	80 – 100	80	-
3	80	65	50
4	65	50	40
5 - 6	50	40	30

Notes
Terrain: typical cross-slopes
Plain: 0 – 10%
Rolling: 11 – 25%
Hilly: >25%

Table 9.3.4 Design Parameters Related to Design Speed

Design Speed (km/h)	Sight Distance (m)			Maximum Curvature Values	
	SSD	ISD	OSD	Horizontal Curve (Radius m)	Vertical Curve (K value)
Two lane roads					
30	30	60	120	35	2
40	45	90	180	65	4
50	60	120	250	120	9
65	90	180	360	250	18
80	120	250	500	500	35
100	180	360	720	1,000	70
Single lane roads					
30		60		120	4
40		90		250	9
50		120		500	18
65		180		1,000	35
Dual carriageway roads					
50		120		500	18
65		180		1,000	35
80		250		2,000	70
100		360		4,000	140

Notes:
1. This is a summary table – refer to the appropriate sections of the manual before using these parameters
2. Sight distances (see Section 2.6) SSD – Stopping Sight Distance; ISD - Intermediate Sight Distance; OSD – Overtakin Sight Distance
3. Horizontal curves (see Section 5) The radii are those needed to achieve SSD with 5% superelevation (3% for the 100 radius curve)
4. Vertical curves (see Section 6) Two lane roads: K values are those needed to achieve SSD; Single lane roads: K valu are those needed to achieve ISD
5. For parameters relating to dual carriageway roads refer to the appropriate sections of the manual

Regional Highways at least should fulfill the requirement for geometric standards for the design speed of 80 km/h, though the Design Standards do not directly relate the road classification to the design speed, rather putting an emphasis upon the traffic volume.

Instead, the Study Team considers that, apart from other geometric components, the cross section of the Project highway is more dependent on the characteristics of the Project highway as well as the traffic volume. Particularly, the number of lanes will be determined for each of the alternative Project highways, based on the design traffic volumes to be forecasted and applied to each alternative.

However, a standard configuration for the cross section should be established, regardless of the planned number of lanes, based on the characteristics of the Project highway. The basic policy in this regard would be summarized as follows:

- For safety, the dual carriageway should be provided, consequently leading to provision of the median barrier in the cross section.
- The safety and operation issue requires provision of turnouts at a certain interval, but recently it has been pointed out that turnouts with a short spacing are much inferior to the continuous hard shoulder from both operation and construction aspects. Therefore, a hard shoulder in an appropriate width should be provided in the cross section on the entire Project highway, even on the long bridge.
- Considering the nature of the arterial highway, non-motorized vehicles and pedestrians should not be accessible to the Project highway. Thus, non-motorized vehicle lanes should not be provided in the typical cross section.

Following these basic policies, a schematic cross section of the Project highway is proposed as in Figure 9.3.2. Components other than road traffic affecting the configuration of the cross section, such as railway, electricity, gas pipes and communication lines, should be considered specifically for each alternative Project location.

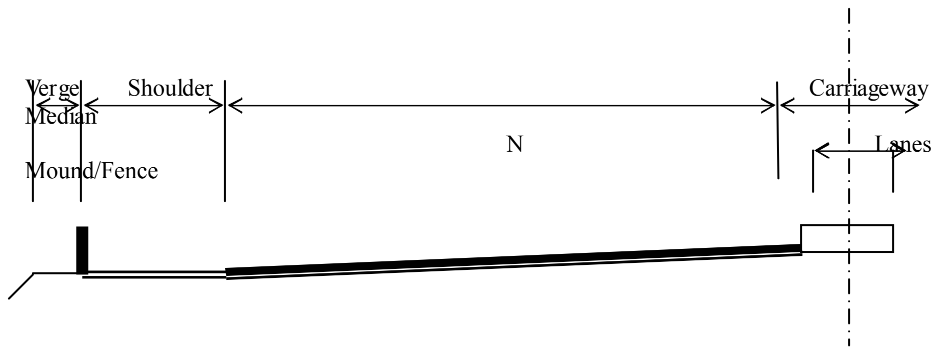


Figure 9.3.2 Schematic Typical Cross Section of Project Highway

9.4 HIGHWAY DEVELOPMENT IN AREA ASSOCIATED WITH PADMA PROJECT

As mentioned in 9.3, the nationwide arterial highway and road network under RHD has presently a total length of about 21,000 kilometers, whereas the local roads under LGED about 206,000 kilometers. For the RHD road administration, the whole country consisting of 64 Districts under six Divisions is divided into 16 Circles in total, and portions of the nationwide RHD road network are separately administered by each of the RHD offices located in the Circle. On the other hand, each portion of the local road network which is enormous in quantity in national total is administered by each local government with technical and financial assistance of LGED. The distribution of all roads under RHD and LGED over the Circles is shown in Table 9.4.1.

Among those Circles, the Study Team selects the Faridpur, Barisal, Jessore and Khulna Circles in the Southwest Region and some part of the Dhaka Circle in the North Central Region as the associated area with the prospective Padma crossing, based on the recognition that the Project is supposed to influence directly the regional linkage between the Southwest and North Central Regions.

The present RHD road network in the region around this associated area is as shown in Figure 9.4.1. Also, the current condition of the RHD road network in the associated area, expressed by the road surface types, as summarized in Figure 9.4.2 and Table 9.4.2, clearly shows that development of the highways and roads in the Southwest Region is far below the national average achievement, while that in the Dhaka Circle considerably exceeds it.

On the contrary, development of the local roads under LGED such as the Upazila, Union and Village Roads has been advanced somewhat more in the associated area than the national average. But there is no distinctive difference in the development achievement between the Southwest Region and the Dhaka Circle, as shown in Table 9.4.3 and Figure 9.4.3.

This indicates that the development of local roads as a whole still remains at quite low a level while that of arterial highways, though still insufficient in whole quantity, has been relatively advanced but with considerable regional biases, as typical as between the Southwest Region and the Dhaka Circle. The Project highway is expected to play an important role to rectify this significant regional gap.

Table 9.4.1 Regional Distribution of Roads under RHD and LGED

REGION	DIVISION	CIRCLE	RHD ROAD (KILOMETERS)				LGED ROAD (KILOMETERS)				TOTAL
			NATIONAL HIGHWAY	REGIONAL HIGHWAY	ZILA ROAD	SUBTOTAL	UPAZILA ROAD	UNION ROAD	VILLAGE ROAD	SUBTOTAL	(KILOMETERS)
NORTH CENTRAL	DHAKA	DHAKA	340	85	887	1,312	1,839	4,766	6,939	13,544	14,856
		MYMENSINGH	232	200	1,823	2,255	2,874	9,634	12,159	24,667	26,922
	SUBTOTAL		572	285	2,710	3,567	4,713	14,400	19,098	38,211	41,778
SOUTHWEST	DHAKA	FARIDPUR	249	158	959	1,366	1,551	3,243	6,241	11,035	12,401
	BARISAL	BARISAL	98	142	1,984	2,224	1,441	5,735	15,391	22,567	24,791
	KHULNA	JESSORE	277	239	997	1,513	2,418	5,604	9,277	17,299	18,812
		KHULNA	63	141	726	930	1,247	3,667	6,800	11,714	12,644
	SUBTOTAL		687	680	4,666	6,033	6,657	18,249	37,709	62,615	68,648
EAST	CHITTAGONG	CHITTAGONG	106	33	503	642	320	2,143	4,690	7,153	7,795
		CHITTAGONG (S)	246	7	1,235	1,488	353	1,122	2,982	4,457	5,945
		RANGAMATI	48	62	608	718	691	2,133	2,775	5,599	6,317
		COMILLA	217	88	1,183	1,488	908	3,778	6,768	11,454	12,942
		NOAKHALI	79	51	1,001	1,131	651	2,650	6,390	9,691	10,822
	SYLHET	SYLHET	275	84	930	1,289	1,690	3,874	7,702	13,266	14,555
	SUBTOTAL		971	325	5,460	6,756	4,613	15,700	31,307	51,620	58,376
NORTHWEST	RAJSHAHI	PABNA	244	20	695	959	877	2,982	3,354	7,213	8,172
		RAJSHAHI	58	180	689	936	1,824	5,071	6,889	13,784	14,720
		DINAJPUR	185	69	599	853	1,434	4,112	6,127	11,673	12,526
		RANGPUR	369	183	1,143	1,695	3,316	8,110	9,642	21,068	22,763
	SUBTOTAL		856	452	3,126	4,443	7,451	20,275	26,012	53,738	58,181
TOTAL			3,086	1,751	15,962	20,799	23,434	68,624	114,126	206,184	226,983

Source: ADP Database, RHD, as of 2003, and LGED documents

Figure 9.4.1 Present RHD Road Network in the Associated Area

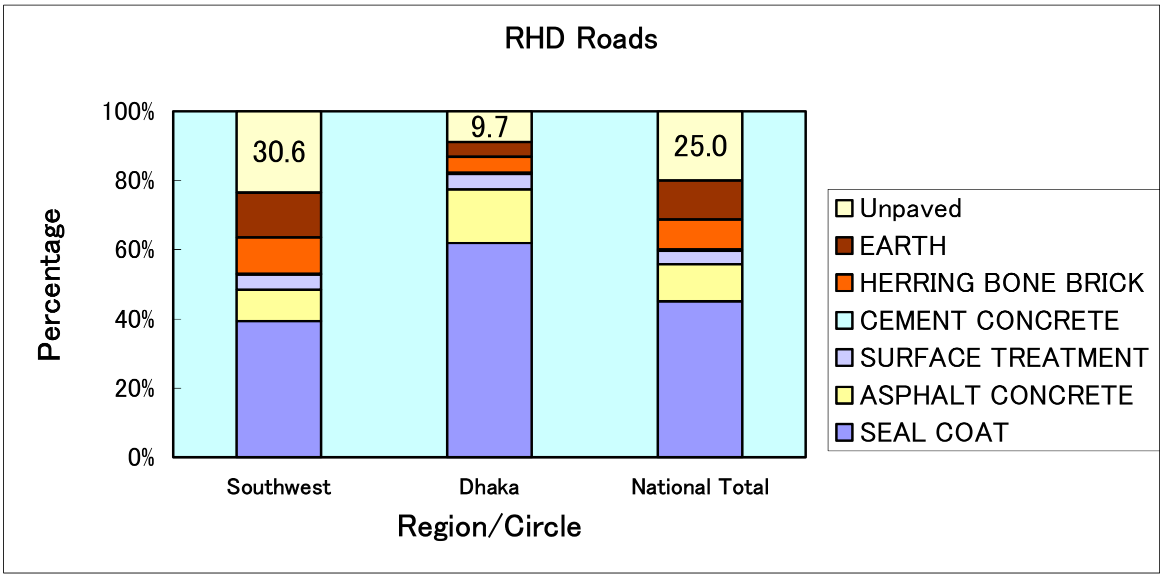


Figure 9.4.2 Road Surface Types of RHD Roads in the Associated Area

Table 9.4.2 Total Lengths of RHD Roads by Road Surface in the Associated Area, as of 2001

REGION	SOUTHWEST						NORTH CENTRAL		NATIONAL TOTAL	
CIRCLE	FARIDPUR	BARISAL	JESSORE	KHULNA	SUBTOTAL		DHAKA			
	KM	KM	KM	KM	KM	%	KM	%	KM	%
TOTAL PAVED ROAD LENGTH	774	1,050	1,098	462	3,384	69.4	837	90.3	12,481	75.0
SEAL COAT	584	903	741	278	2,506	51.4	630	68.0	9,390	56.5
ASPHALT CONCRETE	128	93	234	129	584	12.0	158	17.0	2,222	13.4
SURFACE TREATMENT	59	45	122	54	280	5.7	45	4.9	808	4.9
CEMENT CONCRETE	3	9	1	1	14	0.3	4	0.4	61	0.4
HERRING BONE BRICK	111	340	177	34	662	13.6	46	5.0	1,800	10.8
EARTH	148	452	96	137	833	17.1	44	4.7	2,350	14.1
TOTAL UNPAVED ROAD LENGTH	259	792	273	171	1,495	30.6	90	9.7	4,150	25.0
TOTAL SURVEYED ROAD LENGTH	1,033	1,842	1,371	633	4,879	100.0	927	100.0	16,631	100.0
TOTAL LENGTH OF ROADS NOT SURVEYED	333	382	142	297	1,154		385		4,168	
TOTAL RHD ROAD LENGTH	1,366	2,224	1,513	930	6,033		1,312		20,799	

Source: ADP Database, RHD

Table 9.4.3 Total Lengths of Roads under LGED by Development Status in the Associated Area, as of 2003

REGION		SOUTHWEST						NORTH CENTRAL		NATIONAL TOTAL	
CIRCLE		FARIDPUR	BARISAL	JESSORE	KHULNA	SUBTOTAL		DHAKA			
		KM	KM	KM	KM	KM	%	KM	%	KM	%
UPAZILA ROAD	EXISTING DEVELOPED LENGTH	1,369	781	1,663	908	4,721	70.9	1,198	65.1	15,074	64.3
	TOTAL LENGTH TO BE DEVELOPED	182	660	755	339	1,936	29.1	641	34.9	8,360	35.7
	TOTAL LENGTH	1,551	1,441	2,418	1,247	6,657	100.0	1,839	100.0	23,434	100.0
UNION ROAD	EXISTING DEVELOPED LENGTH	938	1,328	1,664	1,190	5,120	28.1	1,413	29.6	15,942	23.2
	TOTAL LENGTH TO BE DEVELOPED	2,306	4,406	3,940	2,477	13,129	71.9	3,353	70.4	52,682	76.8
	TOTAL LENGTH	3,244	5,734	5,604	3,667	18,249	100.0	4,766	100.0	68,624	100.0
VILLAGE ROAD	EXISTING DEVELOPED LENGTH	361	624	417	484	1,886	5.0	413	7.0	5,504	4.8
	TOTAL LENGTH TO BE DEVELOPED	5,880	14,767	8,861	6,316	35,824	95.0	5,513	93.0	108,621	95.2
	TOTAL LENGTH	6,241	15,391	9,278	6,800	37,710	100.0	5,926	100.0	114,125	100.0
TOTAL LGED ROAD	EXISTING DEVELOPED LENGTH	2,668	2,733	3,744	2,582	11,727	18.7	3,024	24.1	36,520	17.7
	TOTAL LENGTH TO BE DEVELOPED	8,368	19,833	13,556	9,132	50,889	81.3	9,507	75.9	169,663	82.3
	TOTAL LENGTH	11,036	22,566	17,300	11,714	62,616	100.0	12,531	100.0	206,183	100.0

Source: LGED Documents, August 2003

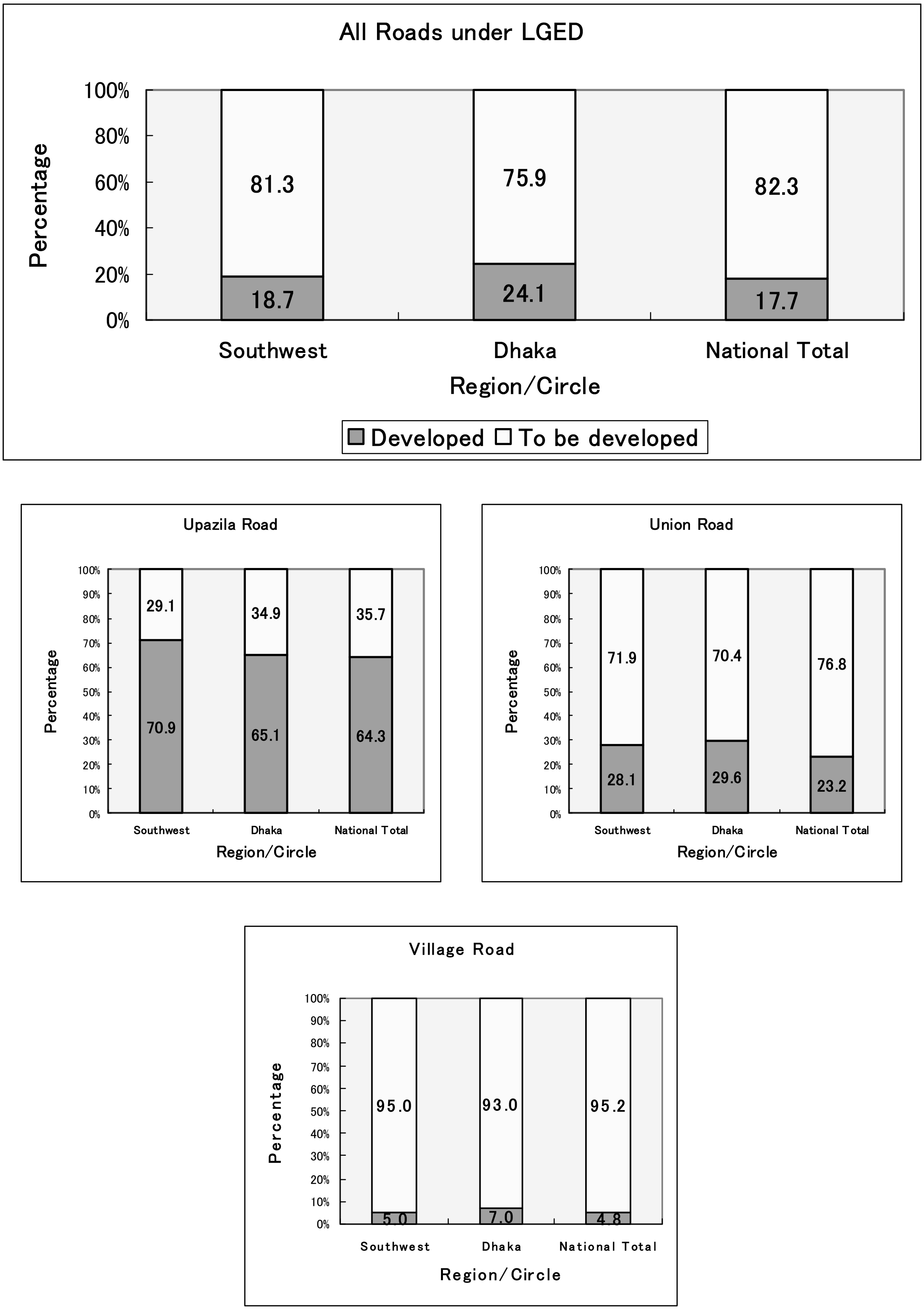


Figure 9.4.3 Roads under LGED by Development Status in the Associated Area

The national and local governments are making efforts to raise the economic and social potential of the Southwest Region and dissolve the regional imbalance of development through a variety of administrative channels. Promotion of infrastructure development is supposed to be one of the most important and effective means to achieve such goals. Most urgently needed would be, particularly, the development of an efficient highway and road network as well as the improvement/rehabilitation/upgrading of existing roads in the region.

In this regard, RHD is implementing a variety of road development projects including construction, improvement, rehabilitation and maintenance of roads and bridges all over the country. Table 9.4.4 is the list of such on-going projects in the associated area, though some of them are not particularly relevant to this area but nationwide projects.

Furthermore, a number of additional road development projects to be funded by foreign aid are under consideration by the Government of Bangladesh, as listed in Table 9.4.5. Some of those on-going and future projects, as described below, will have direct or indirect influence to the planning of transportation, highway and bridge for the Padma crossing Project.

It should be noted firstly that the South-West Road Network Development Project (No. 88 in Table 9.4.4), now in progress by RHD with financial aid of ADB to improve and rehabilitate the National Highway N8 between Dhaka and Noapara, will readily provide the Padma Project highway with a National Highway with a currently atainable utmost grade as connecting roads at both ends, if the Mawa-Janjira is selected as the Padma crossing site.

Also it should be noted that a prospective project named the Construction of Paturia–Dauladia Bridge over the River Padma straight to Uthili-Baruaria (No. 21 in Table 9.4.5) coincides completely with one of the alternative locations of the Padma crossing Project. The Study Team understands that that project No. 21 has been listed as a strong desire and intension of the Government of Bangladeshi to construct a bridge at some location over the Padma River, and that it does not mean one more bridge will be by all means constructed at that particular Paturia location whichever alternative location for this Padma crossing would be selected by this Study.

Among those listed projects, there are two projects closely relevant to the Padma Project in the associated area in the Road Network Improvement and Maintenance Project Ⅰ and Ⅱ under ADB Technical Assistance in 2001 and 2003, respectively, —— one is the arterial highway rehabilitation project on National Highway N76, Regional Highway R760 and some Zila Road between Benapole and Bhatiapara (No. A-1 in Table 9.4.5), and the other is the Regional Highway and Zila Road rehabilitation project in the southwest of Dhaka (No. A-2 in Table 9.4.5).

Substantially influential is the former, the prospective road network improvement project between Benapole and Bhatiapara, which will compose a direct east-west corridor in the central part of the Southwest Region together with the above-mentioned N8, by complementing the missing arterial link between Narail and Bhatiapara, and advantageously bear the major traffic between Dhaka and the Southwest Region if the Padma Bridge is provided at the Mawa-Janjira location. This project is also noteworthy from the aspect of international freight movement between India and Bangladesh, because it will complete the direct linkage between the capital, Dhaka, and a major land port at the border, Benapole, as well as form an important section of the Asian Highway A1.

Both on-going and planned projects, as jointly displayed as Figure 9.4.4, will be significantly interactive with each other as well as with the Padma Bridge.

Table 9.4.4 On-going RHD Road Projects in the Associated Area, as of July 2003

Table 9.4.4 On-going RHD Road Projects in the Associated Area, as of July 2003

Ref. No.	PROJECT NAME	PROJECT PERIOD	TOTAL COST in Mil. Taka	PROJECT TYPE	REMARKS	FUNDING
23	Improvement of Kashinathpur – Kazirhat Road & Natakhola Ferry Approach Road	01/07/96–30/06/05	306.3	Impr./Rehab., Road	Road Length: 16.75 km	GOB only
50	Rehabilitation of Major Roads in Patuakhali and Barguna District	01/07/00–30/06/06	1,127.1	Impr./Rehab., Road	Road Length: 116.00 km	Aided by Denmark
76	Feeder Road at Sariatpur – Gonganagar – Mongol Majhirghat	01/07/98–30/06/04	2,865.9	Impr./Rehab., Road	Road Length: 28.00 km	GOB only
83	Upgradation of Kushita – Meherpur Road to Regional Highway	01/07/99–30/06/04	384.8	Impr./Rehab., Road	Road Length: 58.00 km	GOB only
84	Upgradation of Jessore – Magra Road	01/07/99–30/06/05	264.0	Impr./Rehab., Road		GOB only
88	Development of South-West Road Network	01/03/00–31/12/04*	10,861.5	Impr./Rehab., Road	Road Length: 162.39 km including 1,760 m in total length of 40 bridges	Aided by ADB
7	Thana Connecting Road Project	01/07/00–30/06/15	109,776.1	Impr./Rehab., Road		GOB only
13	Public Priority Road & Bridge Project	01/07/94–30/06/06	15,403.2	Impr./Rehab., Road		GOB only
36	3rd Road Rehabilitation & Maintenance Project	01/07/98–30/06/04	25,313.7	Impr./Rehab., Road		Aided by IDA
121	Road Maintenance & Improvement Project	01/04/01–31/03/05	2,227.5	Impr./Rehab., Road		Aided by ADB
8	Pakshi Bridge over Padma River	01/07/97–30/06/05	10,326.9	Construction, New Bridge	Road Length: 16.00 km Bridge Length: 1786.00 m	Aided by Japan
94	Rupsa Bridge and Khulna City Bypass Road with Link to Rupsa Bridge	01/07/00–30/06/05	7,671.7	Construction, New Bridge	Road Length: 8.555 km Total Length of 3 Bridges: 1,480 m	Aided by DRGA/Japan
157	Bekutia Bridge over Kocha River on Barisal – Jhalokati – Pirojupur – Bagerhat – Khulna Highway	01/07/02–30/06/06	823.0	Construction, New Bridge	Bridge Length: 1500.00 m	GOB only
178	Muniganj Bridge at Dhaka – Mawa – Mollahat – Chitolmari – Bagerhat Link Road in Bagerhat	01/07/01–30/06/05	382.0	Construction, New Bridge	Bridge Length: 433.64 m	GOB only

Source: ADP Database, RHD * updated

Table 9.4.5 Future Road Development Projects by RHD with Foreign Aid in the Associated Area As of September 2003

No.	PROJECT NAME	TOTAL COST		PROJECT TYPE	REMARKS
		Million Taka	Million USD		
2	Improvement of Barisal – Jhalakathi – Bhandaria – Charkhali – Pirojpur – Khulna Highway	1,000.00	20.62	Impr./Rehab., Road	Road Length: 118.5 km Total Bridge Length: 650 m, 22 nos.
10	Construction of Second Sitalakhya, Third Burigonga and Muktapur Bridges	2,500.00	51.54	Costruction, New Bridge	
11	Construction of Dopdapia Bridge on Barisal – Patuakhali Highway	1,000.00	20.62	Costruction, New Bridge	Bridge Length: 850 m
15	Improvement of Faridpur – Barisal (N-84)	2,940.30	57.90	Impr./Rehab., Road	Road Length: 154.0 km
18	Feasibility Study and Upgrading Jessore – Benapole Road including Construction of Diversion Road near Benapole Land Port	1,844.00	36.30	Impr./Rehab., Road	Road Length: 42.4 km
21	Construction of Paturia – Dauladia Bridge over the River Padma straight to Uthili-Baruaria	24,000.00	446.10	Costruction, New Bridge	Bridge Length: 3,000 m
28	Improvement of Khulna – Satkhira – Betkhari Roads	1,008.00	18.74	Impr./Rehab., Road	Road Length: 126.0 km Implementation Period: 4 years
A-1	Improvement of Bhatiapara – Narail – Jessore – Benapole Highway	4,481.10	73.46	Impr./Rehab., Road	Road Network Improvement and Maintenance Project II (RNIMP-II), ADB Road Length: 79.5 km Bridge Length: 500 m
A-2	Improvement of Hemayetpur – Hazratpur – Konakhola, Zinzira – Rubitpur – Dohar – Srinagar – Khakladi – Mushiganj, Fatulla – Moktarpur Ferry, Moktarpur – Tongibari – Louhjang – Mawa and Tongi – Ghorashal Road	7,055.11	115.66	Impr./Rehab., Road	Road Network Improvement and Maintenance Project II (RNIMP-II), ADB Road Length: 194.5 km

Source: RHD Handbook, Dec. 2000 and F/S Report of RNIMP-II, 2003, ADB

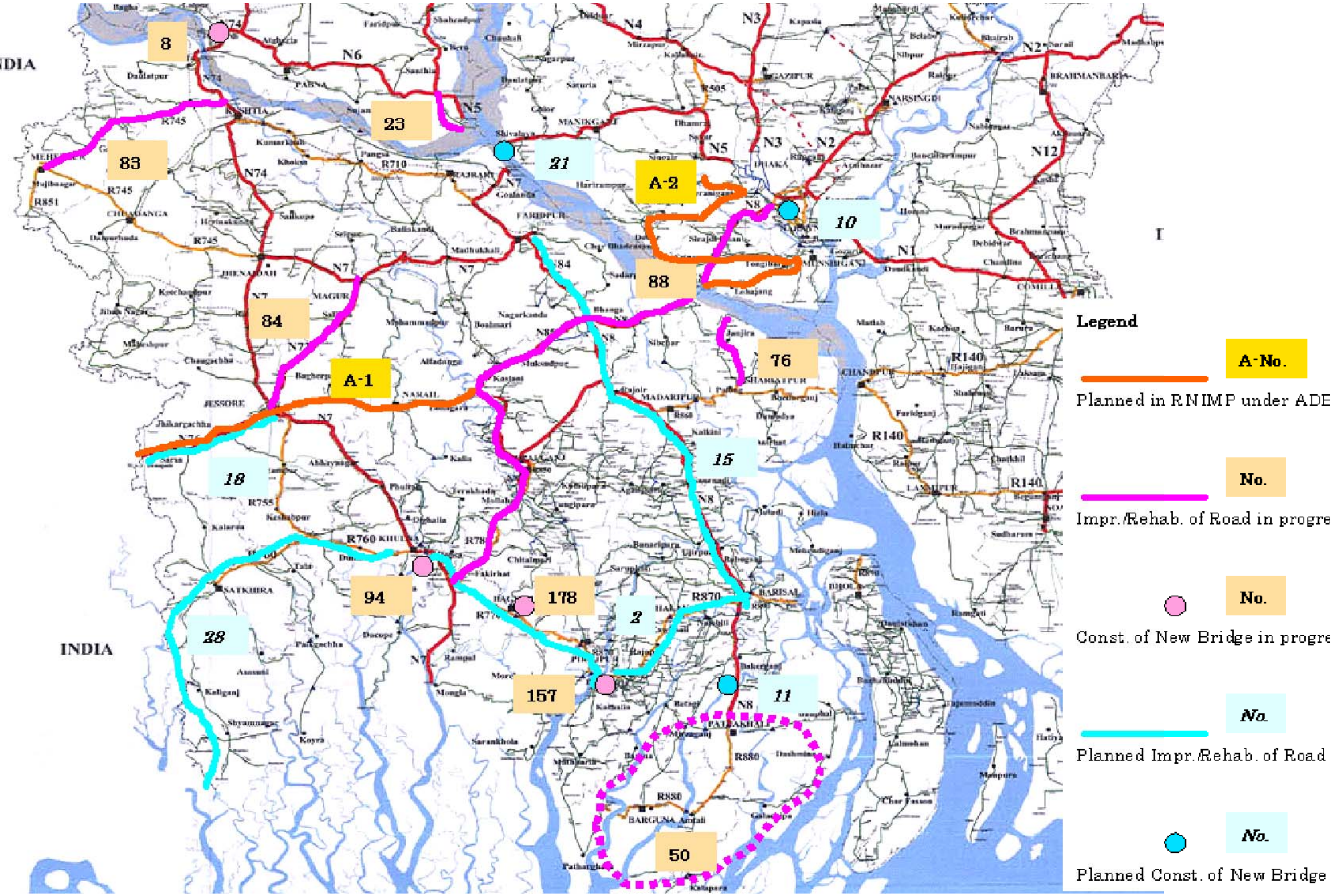


Figure 9.4.4 On-going and Planned RHD Road Projects in the Associated Area

9.5 CHARACTERS OF INITIAL PROJECT LOCATION ALTERNATIVES FROM HIGHWAY PLANNING ASPECTS

The location of the prospective bridge crossing over the Padma River must be comprehensively studied from a variety of aspects. In the Study, as the first stage of selection of the Project location, three major aspects of evaluation of the alternative Project locations are adopted; viz, physical, technical, and environmental and social aspects. Each of these aspects comprises several sub-aspects such as:

Physical Aspects;	River Width, Stability of River, and Flood and Drainage on Bank
Technical Aspects;	Transportation Planning, Highway Planning, Bridge Planning, River Training, and Project Cost
Environmental and Social Aspects;	Natural Environmental Impacts, Land Acquisition, and Resettlement of Residents

As described earlier, four locations which were preliminarily selected prior to the start of the Study; viz,

Site-1, Paturia-Goalundo,
Site-2, Dohar-Char Bhadrasan,
Site-3, Mawa-Janjira, and
Site-4, Chandpur-Bhedarganj,

are also dominantly justified as alternative Padma crossing locations by evaluation from the physical aspects above. They are as shown in Figure 9.5.1.

Evaluation of each of the four location alternatives from the aspect of highway planning is as follows:

(1) Site-1, Paturia to Goalundo

As shown in Figure 9.5.2, the project is supposed to have:

- Bridge length; 6.1 kilometers
- Approach road length on the left bank; 8 kilometers
- Approach road length on the right bank; 3 kilometers, and
- Total length; 17 kilometers.

The Project highway is moderate in both total length and bridge length, and connects to arterial National Highways N5 and N7 on Paturia and Goalundo sides, respectively, which are currently linked by ferry services. These connecting roads are both in good conditions and do not require improvement.

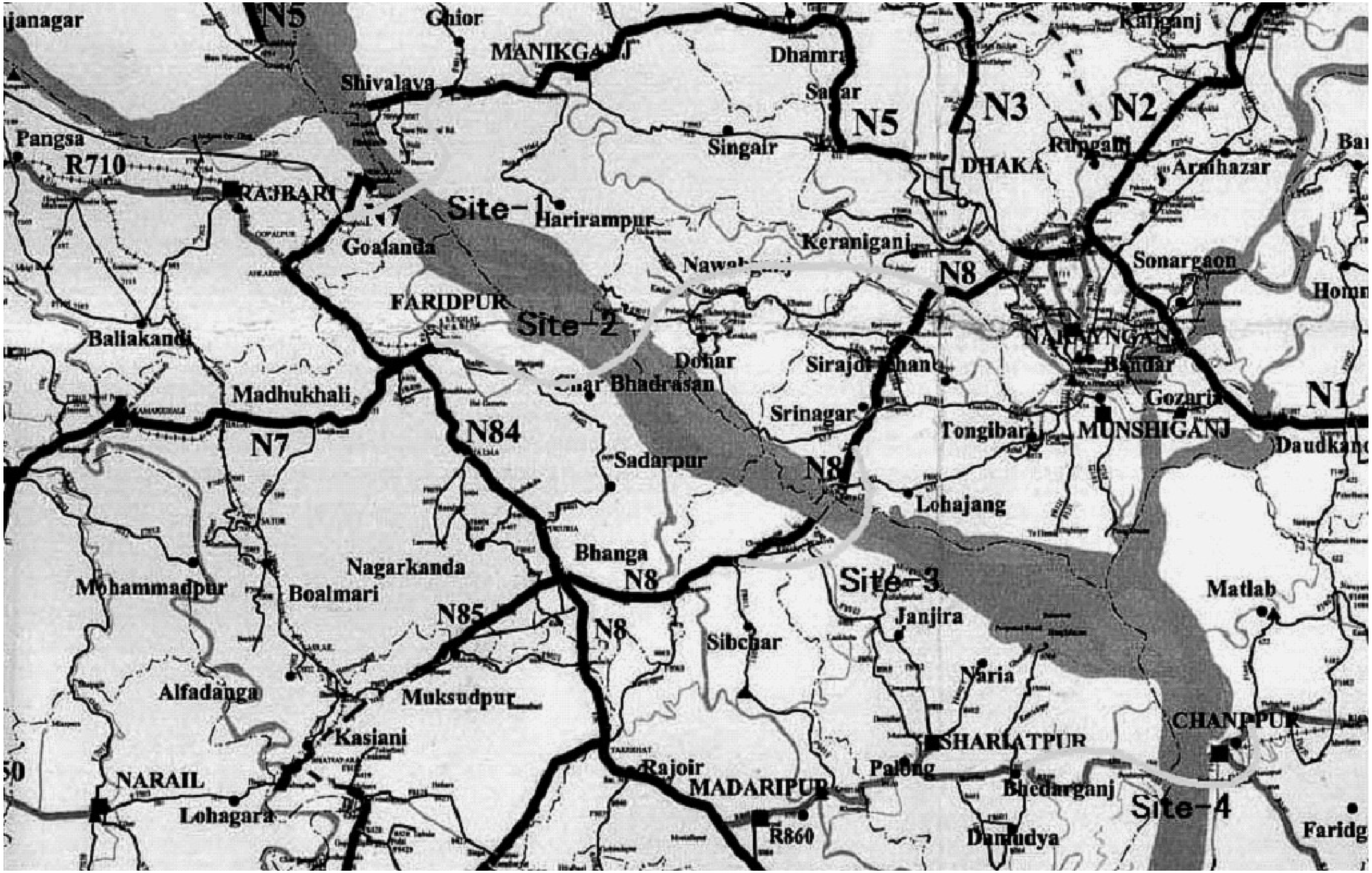


Figure 9.5.1 Alternative Project Locations for the Padma Crossing

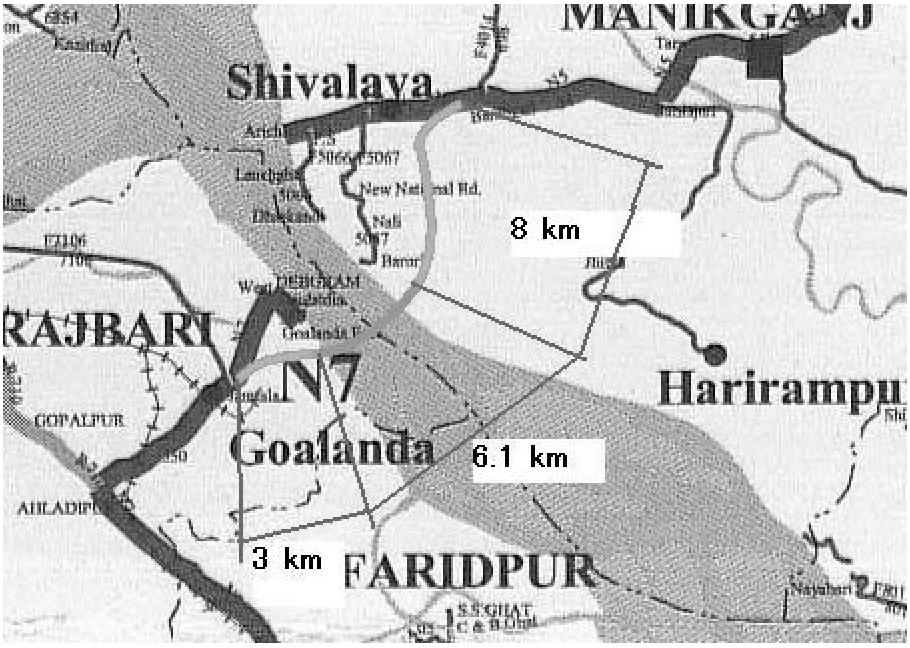


Figure 9.5.2 Project Highway Plan at Site-1

This alternative is geographically rather favorable to traffic from Dhaka to the Northwest Region than to the Southwest Region, the supposed associated area with the Project, and thus somewhat competitive with the Jamuna Bridge. Consequently it is less attractive to most of the Southwest Region than other alternatives.

(2) Site-2, Dohar to Char Bhadrasan

As shown in Figure 9.5.3, the project is supposed to have:

- Bridge length; 9.6 kilometers
- Approach road length on the left bank; 32 kilometers
- Approach road length on the right bank; 16 kilometers, and
- Total length; 57 kilometers.

Among the alternatives, this location requires the longest Project length and relatively longer bridge length to connect the National Highways N8 near Dhaka and N84 at Faridpur with extremely long approach roads on both banks. Though far-away connecting roads on both sides do not need improvement, requirement for construction of these new, long approach roads in the flood plain as well as a relatively long main bridge over the Padma River makes this alternative location quite unrealistic.

This alternative is moderately favorable to the Dhaka-Southwest traffic as a location. But presently there are no ferry linkage, no arterial approach roads, and consequently no traffic. Once a bridge is constructed at this location, the route will significantly compete with the National Highway N8 to be improved/upgraded by the end of 2004 for the traffic between Dhaka and the Southwest Region.

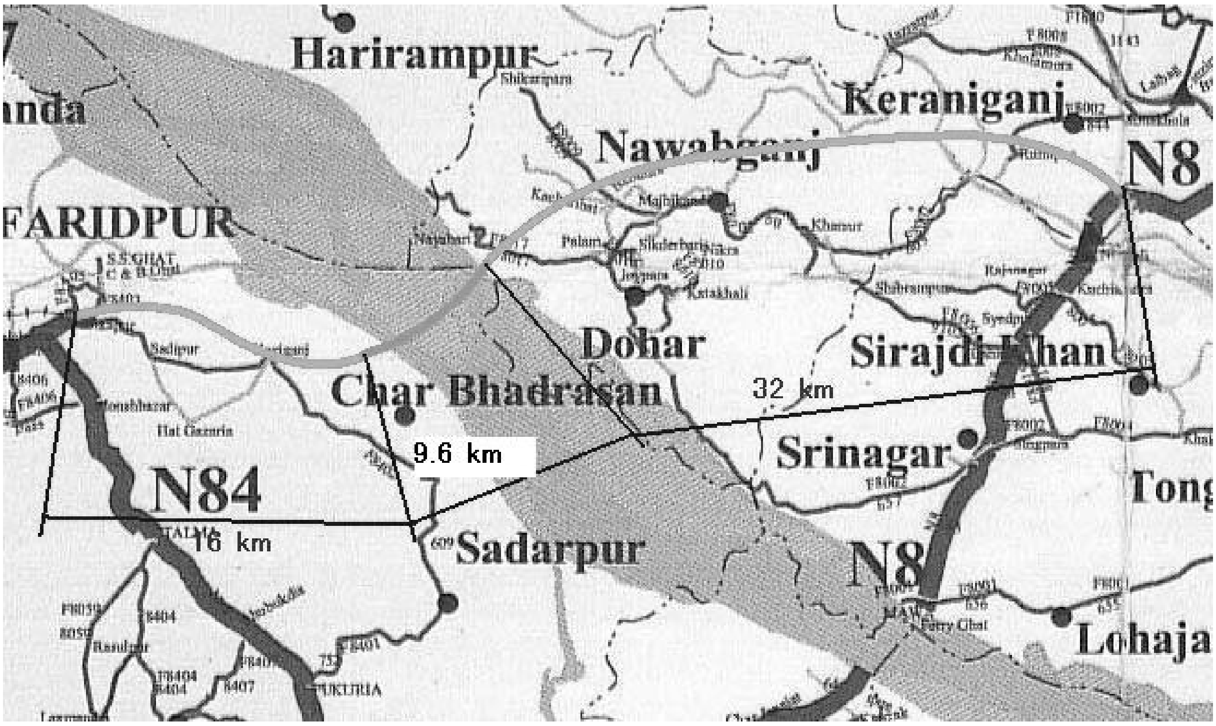


Figure 9.5.3 Project Highway Plan at Site-2

(3) Site-3, Mawa to Janjira

As shown in Figure 9.5.4, the project is supposed to have:

- Bridge length; 6.1 kilometers
- Approach road length on the left bank; 4 kilometers
- Approach road length on the right bank; 9 kilometers, and
- Total length; 19 kilometers.

The Project highway has a moderate total length with a moderately-long bridge to complete a missing link on the National Highway N8 over the Padma River, presently connected by ferry services. The connecting road, N8, on both banks is currently under improvement/rehabilitation with financial assistance of ADB between Dhaka and Noapara in total length of 162 kilometers due to be completed by the end of 2004. The upgraded N8 will readily provide the Project highway at this location with sufficiently high standard connecting roads which are practically attainable.

As stated in Chapter 6, presently less Padma crossing traffic by ferry is counted at this location than at Site-1, Paturia-Goalundo. But the Project highway at this location, together with the improved N8, will be obviously more favorable to the direct Dhaka-Southwest connection than any other alternative locations, due to its optimal geographic position.

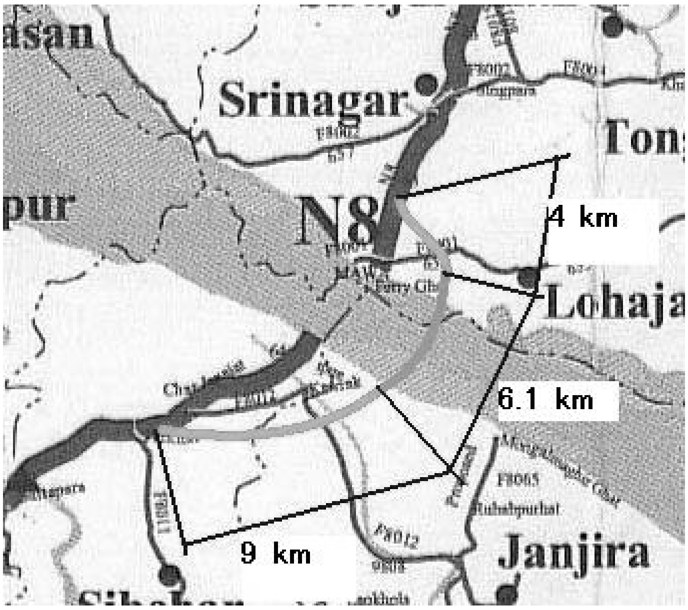


Figure 9.5.4 Project Highway Plan at Site-3

(4) Site-4, Chandpur to Bhedarganj

As shown in Figure 9.5.5, the project is supposed to have:

- Bridge length; 10.8 kilometers
- Approach road length on the left bank; 7 kilometers
- Approach road length on the right bank; 15 kilometers, and
- Total length; 33 kilometers.

The Project at this location has a relatively long Project length and the longest bridge length among the alternatives. The Project highway at this location is to be connected not to National Highways but to the Regional Highways with relatively low standard, R140 at the Chandpur side and R360 at the Bhedarganj side, which are presently connected by ferry services. Significant upgrading/improvement of those connecting Regional Highways will be required.

More serious character of this alternative is that it connects the Southwest Region to Dhaka not directly but partially via the East Region on the left bank of the river. Further, since there is no direct north-to-south arterial highway between Chandpur and Dhaka on the left bank, the Dhaka-Southwest traffic via this Project highway is, between Chandpur and Daudkandi, compelled either to take local Zila Roads with much lower standard or to make a long detour along R140 and N1 via Comilla. In any case it overlaps partially with the Dhaka-Chittagong Corridor.

In these regards, this alternative is somewhat advantageous only for the Chittagong-Southwest traffic, if any, but least favorable to the Dhaka-Southwest connection.

Moreover, though maybe unimportant, it is noteworthy that the river crossing at this location is not over the Padma River but over the Meghna River.

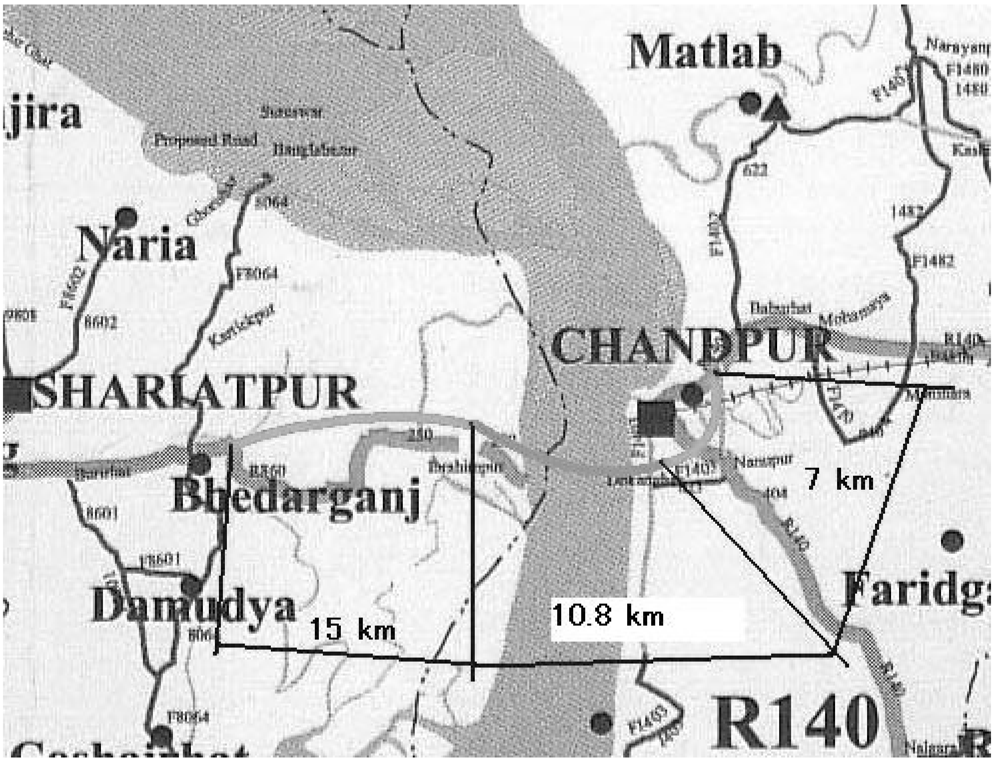


Figure 9.5.5 Project Highway Plan at Site-4

9.6 EVALUATION OF INITIAL PROJECT LOCATION ALTERNATIVES FROM HIGHWAY PLANNING ASPECTS

Evaluation of the Project at the four alternative locations from the aspects of highway planning, as described above, is summarized as in Table 9.6.1.

As a conclusion, the Site-3 and Site-1 are evaluated as the most and the second most advantageous alternatives, respectively, from the highway planning aspect. Consequently, the other two alternatives, Site-2 and Site-4, are excluded from the prospective Padma crossing locations as a result of the first stage screening from the highway planning aspects, as well as from the physical and other technical aspects.

Table 9.6.1 Comparison of Alternative Project Locations from Highway Planning Aspect

Aspects	Paturia-Goalundo Site-1	Dohar-Char Bhadrasan Site-2	Mawa-Janjira Site-3	Chandpur-Bhedarganj Site-4
Highway Planning				
Project Length	17 km Bridge: 6.1 km Approach Roads: LBS 8 km RBS 3 km Total 11 km	58 km Bridge: 9.6 km Approach Roads: LBS 32 km RBS 16 km Total 48 km	19 km Bridge: 6.1 km Approach Roads: LBS 4 km RBS 9 km Total 13 km	33 km Bridge: 10.8 km Approach Roads: LBS 7 km RBS 15 km Total 22 km
Connecting Roads	N5 and N7	N8 and N84	Both N8	R140 and R360
Particulars	Moderate project length, moderate bridge length Connects arterial National Highways presently being linked by ferry services Improvement of connecting roads not required Less favorable to Dhaka-Southwest connection More favorable to Dhaka-Northwest connection Somewhat competitive with Jamuna Bridge	Project length too long due to too long approach roads and relatively longer bridge Improvement of connecting roads not required, but construction of new, long approach roads in the flood plain on both sides required Presently no traffic due to lack of arterial approach roads and ferry linkage Moderately favorable to Dhaka-Southwest connection Significantly competitive with N8 to be upgraded	Moderate project length, moderate bridge length Completes an arterial National Highway link presently missing and ferry services being provided Improvement of the connecting road, N8 between Dhaka and Noapara, in progress to be completed by the end of 2004 More favorable to Dhaka-Southwest connection	Longer project length, longest bridge length Connects arterial Regeonal Highways presently being linked by ferry services Improvement and upgrading of connecting roads considerably required Least favorable to Dhaka-Southwest connection due to ralizing no direct linkage between the two Regions but indirect one partially via the East Region compelling a long detour or use of low standard local roads
Comparative Advantage	**	*	***	*

9.7 BASIC HIGHWAY CONDITION ANALYSIS FOR FINAL SELECTION OF PROJECT LOCATION

Through the first-stage comprehensive screening of the four alternative locations, two crossing sites, Paturia-Goalundo and Mawa-Janjira, are selected as the second-stage project location alternatives. On top of the first-stage study and evaluation, some in-depth analysis and comparison of the conditions and prospective features of the highway between the two alternative locations are conducted from the highway planning aspect.

9.7.1 Connecting Roads

Site-1 (Paturia)

The Project Highway will be connected to the N5 Highway at the Paturia side and the N7 Highway at the Goalundo side, respectively. Presently, the connecting roads at the assumed connecting sections are two-way, two-lane highways with a fair condition of the surface treatment pavement. The existing road embankment of these highways has 1:1.5 to 1:3.0 slope gradient with the turf or grass protection. The existing ground surface condition is cultivated or swampy land, and the embankment at the connecting sections are assumed to be about 3m to 5 m high above the ground.

Site-3 (Mawa)

The Project Highway will be connected to the N8 Highway on the both river banks (Mawa and Janjira). The N8 Highway is being improved up to an arterial highway with two-lane asphalt concrete surface under a road improvement project financed by ADB. The Project Highway will be connected to this improved N8 project road alignment.

The proposed road structure of the N8 highway project is composed of a 7.3m carriageway plus a 2.7m shoulder and a 1:2.0 embankment slope at both sides. The design height of the N8 embankment near the connecting points will be about 3m to 5 m high above the cultivated or swampy ground in the vicinity.

9.7.2 Traffic Demand Forecasts

Future traffic in the year of 2015 and 2025 is estimated by the Study Team as follows:

Table 9.7.1 Future Traffic Forecast

Description		Site-1 Payuria-Goalundo		Site-3 Mawa-Janjira	
		Vehicles per day	Composition %	Vehicles per day	Composition %
Year 2015	Light Vehicle	2,410	23.4	3,850	18.1
	Bus	4,880	48.7	13,210	62.1
	Truck	3,010	28.0	4,200	19.8
	Total	10,300	100.0	21,260	100.0
Year 2025	Light Vehicle	4,610	23.2	7,340	17.7
	Bus	9,920	50.0	26,750	64.4
	Truck	5,320	26.8	7,460	18.0
	Total	19,850	100.0	41,550	100.0

Note: Average Composition ratio 2015－2025 Site-1=Light Vehicle 23.3%, Bus 48.7%, Truck 28.0%
Site-3=Light Vehicle 17.9%, Bus 63.3%, Truck 18.9%

9.7.3 Heights of Project Highway

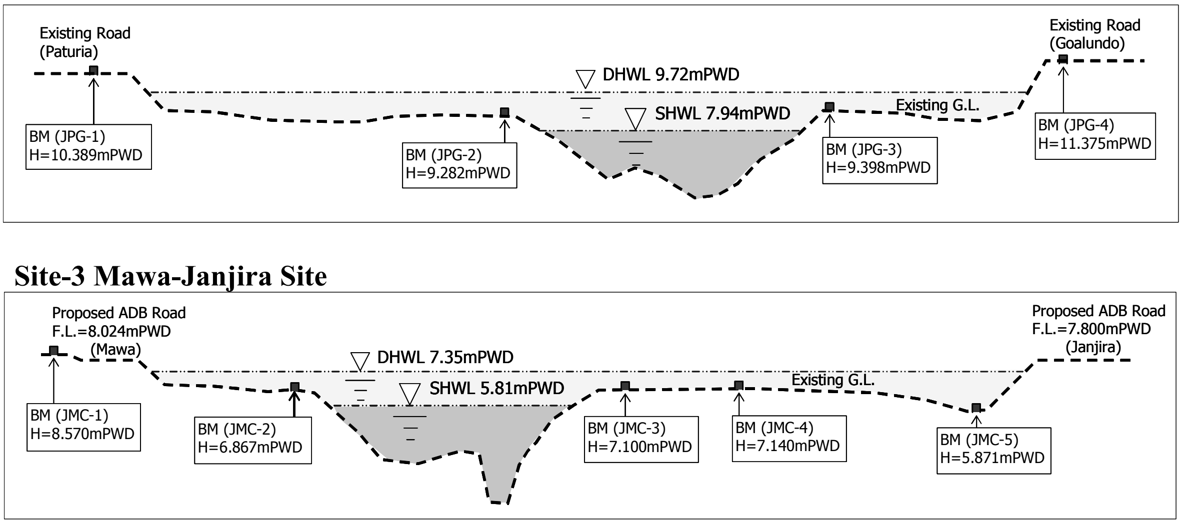
Topographic survey was conducted with the Bench Marks established along the assumed survey lines at the two sites. The survey provides the heights of the existing ground and the connecting points of the existing roads to the survey line for both sites, as follows:

- Site-1: Left bank=10.389mPWD, Right bank =11.375mPWD
- Site-3: Left bank=8.024mPWD, Right bank=7.800mPWD

The Design High Water Level (DHWL, 100 years flood level) is set up in the river study of the Study as 9.72mPWD at Site-1 (Paturia) and 7.35mPWD at Site-3 (Mawa).

As a result of comparison of the existing road level with DHWL, it is found out that the existing roads of both alternative sites (Site-1, 3) are higher than DHWL and this leads to an adequate fulfillment of the required condition for the connecting point between the approach road.and the existing road.

Site-1 Paturia-Goalund Site



Note: Not to Scale
DHWL=Design High Water Level, SHWL=Standard High Water Level , BM=Bench Mark

Figure 9.7.1 Project Height

9.7.4 Potential Highway Routes for Second-Stage Project Location Alternatives

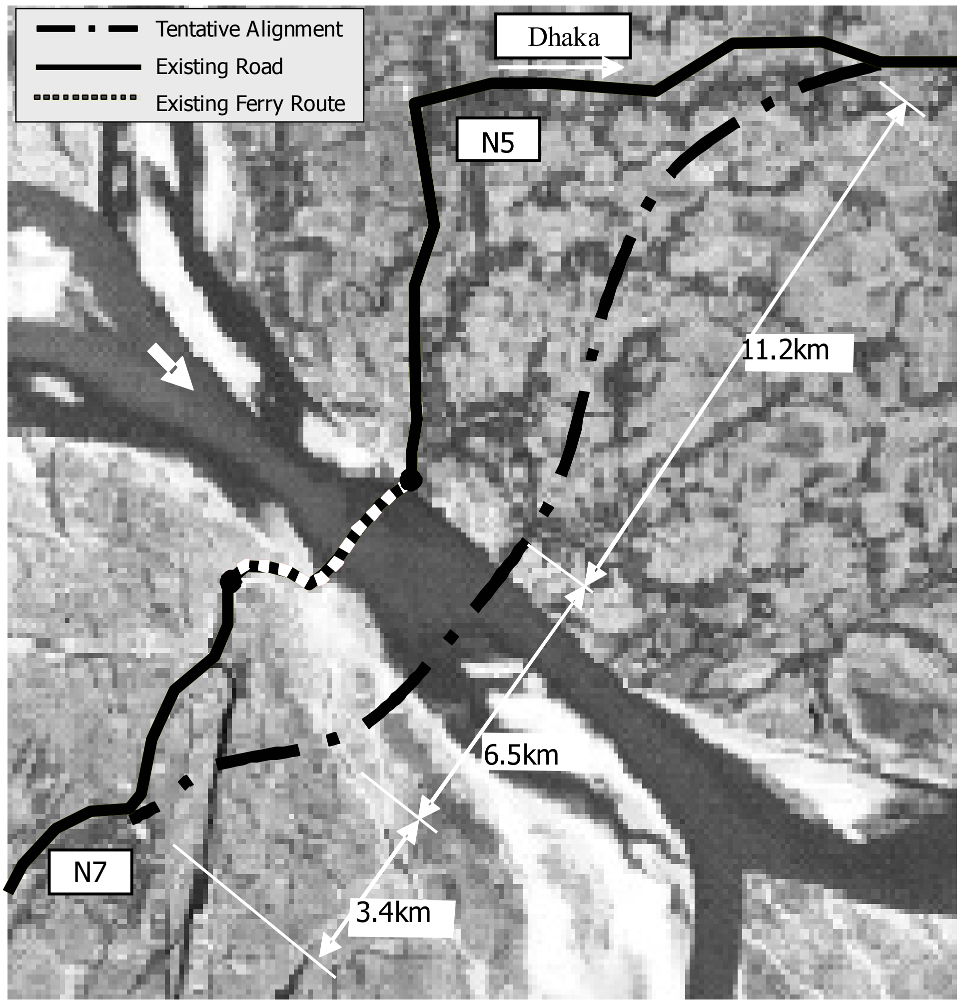
Based on the site conditions and the results of the initial inventory study, the features of the alignment of the two alternative project sites are summarized. Generally, no big difference is observed between the two alternative sites in terms of highway design.

9.7.5 Evaluation of Second-Stage Project Location Alternatives

Though evaluation from the highway planning aspect has detected no distinct advantage or disadvantage between the two, except for the contribution to the smooth development of the Dhaka-Southwest Region traffic corridor, the Mawa-Janjira site is selected as the final Project location, as a result of the overall evaluation.

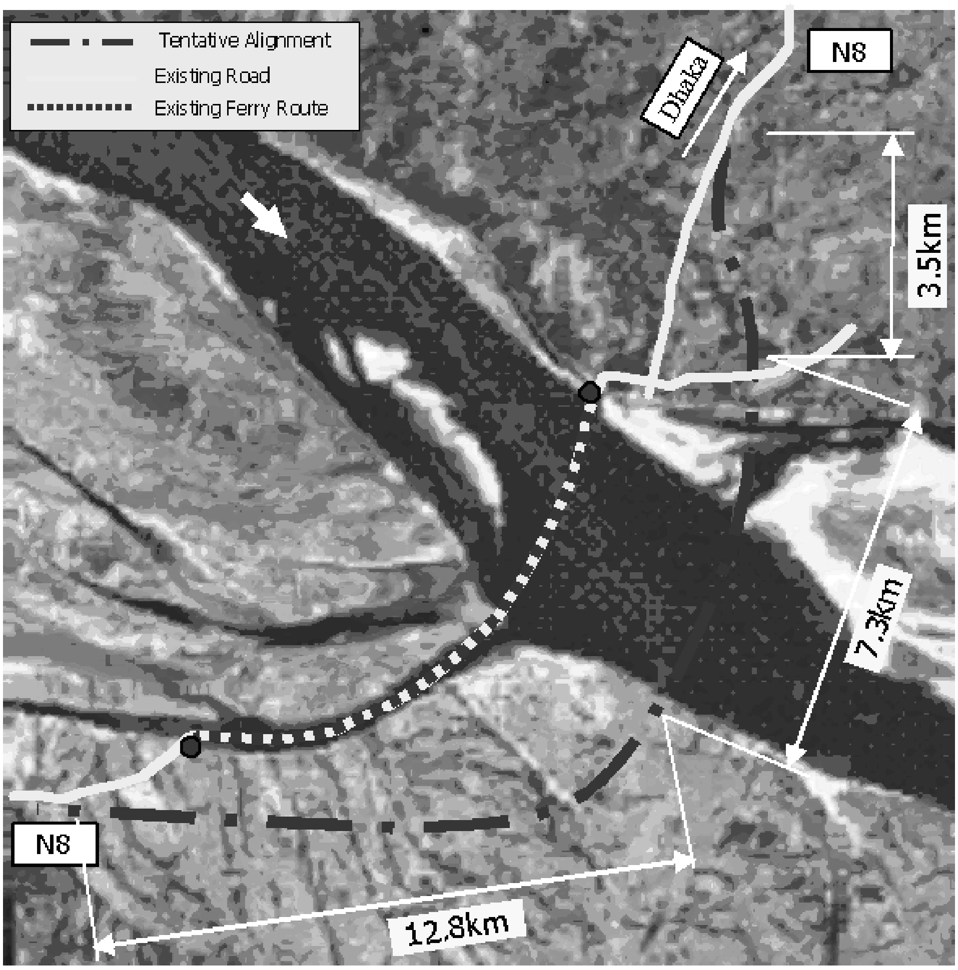
(1) Paturi-Goalundo Alignment Plan (PG-3)

Description			Quantity	Remarks
1. Length	Bridge		6.5km	
	Approach Roads	Left bank	11.2km	Paturia side
		Right bank	3.4km	Goalundo side
		Subtotal	14.6km	
	Total		21.1km	
2. Number of Lanes			4	ADT 19,850 vehicles (2025)
3. Slope gradient			1:3	RHD Standard
4. Land acquisition area (expected)			128ha	Road 85ha＋Borrow pit 43ha
5. Major Structures		Box culvert	9 Nos.	Grade crossing with minor road
		Minor bridge	3 Nos.	Length 460m (Inland river, Railway)
		Toll facility	2 Nos.	



(2) Mawa-Janjira Alignment Plan (MJ-3)

Description			Quantity	Remarks
1. Length	Bridge		6.2km	
	Approach Roads	Left bank	3.5km	Mawa side
		Right bank	12.8km	Janjira side
		Subtotal	16.3km	
	Total		22.5km	
2. Number of Lanes			4	ADT 41,550 vehicles (2025)
3. Slope gradient			1:3	RHD Standard
4. Land acquisition area (expected)			144ha	Road 96ha＋Borrow pit 48ha
5. Major Structures		Box culvert	22 Nos.	Grade crossing with minor road
		Minor bridge	7 Nos.	Length 371m（Inland river）
		Toll facility	2 Nos.	



9.8 DESIGN STANDARD AND CRITERIA FOR PRELIMINARY HIGHWAY DESIGN

The work of the preliminary highway design for the Padma Bridge Project primarily comprises;

- Set-up of the design standard and criteria to be applied,
- Geometric design, both horizontal and vertical, of the entire Project highway,
- Preliminary design of the approach roads, inclusive of;
  - Embankment,
  - Service roads,
  - Pavement, and
  - Minor structures, including bridges and culverts on the approach roads, and
- Plan of the associated facilities such as;
  - Toll plazas, and
  - Service area.

For designing a highway, it is commonly required that the type and function of the highway be identified according to some principle of road classification. The highways and roads are, typically in most standards, classified by;

- Road type: Access-controlled, or not,
- Area of the road: Rural, or Urban,
- Terrain of the area: Level, (or Rolling), or Mountainous, and
- Traffic level in the target year: ex. ADT ranking.

By identifying such attributes, a highway is ranked to a class of the applied standard and, usually a corresponding design speed is specified.

As shown in Table 9.8.1, the highway of the Padma Bridge Project is to be planned as a highway with full control of access in the rural area on the flat terrain, and the traffic demand is forecasted as 41,550 vehicles a day for the target year, 2025, ten years after commissioning. Accordingly, the Project highway will be assigned to a rather high-grade class of any standard to be applied with a design speed of 80 km/h, at lowest.

Table 9.8.1 Road Classification Principle from Geometric Design Aspect

	General Case	Padma Bridge Project
Road Type	Control of access, or No control of access	Control of access
Area	Rural, or Urban	Rural
Terrain	Level, (or, Rolling,) or Mountainous	Level
Traffic Projection for Target Year	ADT ranking	41,550 vehicles per day for 2025

↓

General Case	Padma Bridge Project
Road Class No. of lanes Design Speed	Clear the relevant Standards requirement 4 lanes > 80 km/h

There are two potential design standards to be possibly applied to the preliminary design of the Project highway, ——— namely,

- RHD Geometric Design Standards of Bangladesh, and
- Asian Highway Classification and Design Standards of the UN ESCAP,

because, once it is constructed, the Project highway will certainly become a part of the National Highway No.8 (NH8) of Bangladesh. As well, it is listed in the UN ESCAP Intergovernmental Agreement of 26 April, 2004 as a link of the Asian Highway Route 1 (AH1). It is known that those two standards are both based upon the AASHTO Policy on Geometric Design of Highways and Streets. As a basic policy for designing the Project highway, these two standards are to be jointly applied to the geometric design in coordination with each other, ――― consequently, leading inevitably to adoption of a higher standard of the two on each design aspect.

Table 9.8.2 shows main features of the geometric design, specified by the two standards, as well as the Japanese standards for reference purpose only. The Project highway, having such attributes as shown in Table 9.8.1, is classified as;

- Type-2 (design speed; 80 km/h) of the RHD Geometric Design Standards, and
- Primary, Level Terrain (design speed; 120 km/h) of the Asian Highway Classification & Design Standards.

[If the Road Structure Ordinance of Japan is applied, it corresponds to its 1-2 (Class 1, Level 2) with the design speed of 100 km/h.]

Table 9-8-2 Main Features of Relevant Geometric Design Standards

Standards	Bangladesh	UN ESCAP	Japan
	RHD Geometric Design Standards	Asian Highway Classification & Design Standards	Road Structure Ordinance
Classification	Type−2	Primary, Level Terrain	1−2
Design Speed	80 km/h	120 km/h	100 km/h
No. of Lanes	4	−	4
Horizontal Alignment			
Minimum Curve Radius, Desirable (Absolute)	400 m (280 m)	1,000 m (520 m)	700 m (380 m)
Transition Curve Omission	R > 2,000 m	R > 2,100 m	R > 3,000 m
Minimum Curve Length	−	−	170 m
Minimum Transition Curve Length	−	100 m	85 m
Vertical Alignment			
Maximum Longitudinal Gradient	4 %	4 %	3%
Critical Slope for Climbing Lane		3 % − 800 m	−
Minimum Vertical Curve Radius			
Crest, Desirable (Absolute)	4,500 m (3,000 m)	−	10,000 m (6,500 m)
Sag, Desirable (Absolute)	3,000 m (2,000 m)	−	4,000 m (3,000 m)
Cross Section			
Lane Width	3.65 m	3.5 m	3.5 m
Carriageway	7.3 m(2x3.65)	7.0 m(2x3.5)	7.0 m(2x3.5)
Median	1.6 m(2x0.3+1.0)	4.0 m	Desirable Min. 4.5 m(2x0.75+3.0) Absoluet Min. 3.0 m(2x0.5+2.0)
Shoulder	2.7 m(Hard S. 1.8m)	3.0 m	Desirable Min. 2.5 m Absolute Min. 1.75 m
Total Width (Effective Width)	21.6 m (19.8 m)	(24.0 m)	(23.5 m)
ROW	−	50 m, desirably	−
Crossfall	—	2 %	1.5 % − 2.0 %
Maximum Superelevation	—	10 %	10 %

As for determination of the number of lanes to be provided for a planned highway, formalistic application of an existing standard does not necessarily fit the practical requirement in many cases. Rather, most standards do not have suitable provisions for determining the number of lanes of a planned highway.

In fact, both the RHD and Asian Highway standards, which are to be applied to the geometric design of the Project highway, do not contain appropriate provisions for the number of lanes. Therefore, the number of lanes on the Project highway has been planned as two lanes in one direction (four lanes in total), based on the objective judgment of the planned highway conditions and the projected traffic demand, referring to the relevant provisions of the Road Structure Ordinance of Japan.

9.9 GEOMETRIC DESIGN OF PROJECT HIGHWAY

9.9.1 Route Selection for Project Highway

The route of the Project highway to be proposed at the Mawa-Janjira site by the Study has been selected through investigation and analysis of the following conditions.

(1) Existing Road Network

The Project highway to be planned at this location has a character that it supplements an important, but missing, link on the National Highway No.8 (NH8) over the Padma River. This naturally leads to the primary requirement that its route smoothly connect some existing points on NH8 on both river banks. Thus, the connecting point at the Mawa side is set to be exactly the ending point of the rehabilitated NH8, while that at the Janjira side a point on the newly aligned NH8 near the Charjanajat ferry ghat.

Between the two connecting points to NH8, the Project route crosses several roads including one Regional Highway, 13 local roads under LGED, and some minor trails in the plain on the right bank of the Padma River, as shown in Figure 9.9.1, but no crossing road on the left bank. Also, there are no roads in the direction in parallel with the Project route. Since it will overpass all these crossing roads with grade separation, routing of the Project highway is not primarily affected by this existing local road network.

(2) Topography and River Conditions

The topography of the Project area is dominantly characterized by a world-class major river and its flood plain. The river crossing location has been selected primarily by river engineering screening, taking into account the relative natural stability of the river bank and applicable measures to artificially stabilize the river bank. As the possibly desirable crossing points, the outcomes from the river engineering investigation of the Study provided a certain area upstream of NH8, but by no means downstream of NH8 itself, on the left bank and about 2 km downstream of the mouth of the South Channel on the right bank. Subject to this river engineering constraint, the river crossing points on the both banks are fixed, and routing of the approach roads has been drawn in the flood plain on the right bank toward the ending point. There are several crossing inland waterways and water-logging areas, as shown in Figure 9.9.1, which are, more or less, unavoidable, no matter how the Project routing is managed.

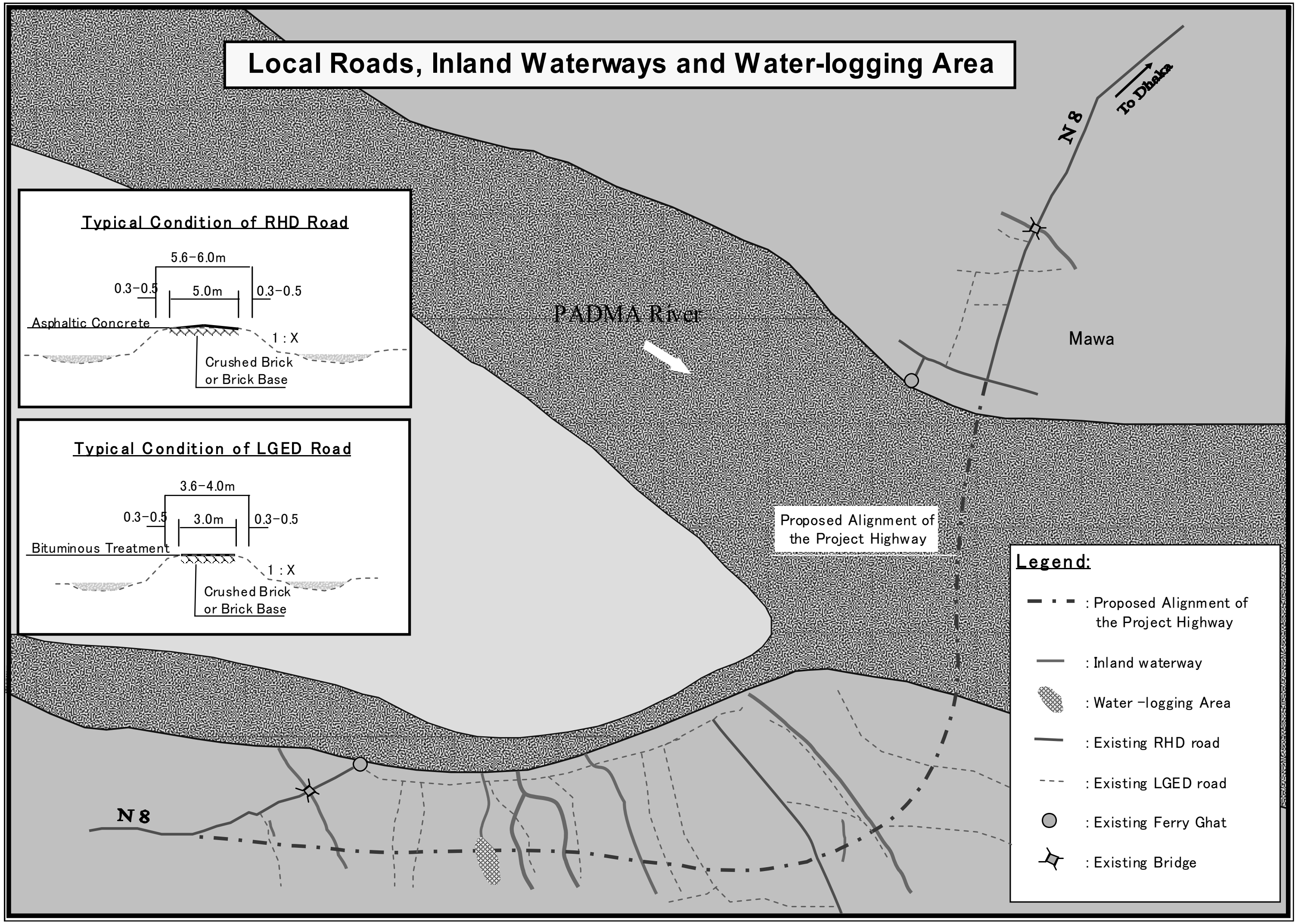


Figure 9-9-1 Local Roads, Inland Waterways and Water-logging Areas

(3) Geology

The Project area is a flood area almost uniformly covered mainly by the sandy soil, which alone hardly affects in any manner the routing of the Project highway. But the river crossing point on the left bank was selected due to the soil condition which has been considerably contributing to the stability of the river bank.

(4) Social Impact Consideration

There are several scattered communities in the Project area on the right bank of the Padma River. In those communities homesteads are located mostly along the local roads which the Project highway inevitably crosses. Though routing of a new highway in the densely populated country such as Bangladesh by no means can make such impacts as relocation of properties and resettlement of residents absolutely nil, routing of the approach road sections of the Project highway can be managed to avoid relocation of some valuable public/private properties, or reduce the number of affected homesteads, or minimize the community severance, to some extent. In this regard, the Project route near the ending point of the right bank approach road is set so as to comparatively reduce the number of severed communities located almost in parallel with each other. But however is the route of most of the entire approach road selected, land acquisition for the Project inevitably causes some amount of relocation and resettlement.

(5) Environmental Consideration

For assessing the environmental impacts of the Project highway, many positive and negative parameters have been already identified through screening in the Study. They include erosion and siltation, agricultural/vegetation loss, fisheries, ecology, navigation, traffic accidents, and air, noise and vibration pollution. But any particular parameters which significantly affect the routing of the Project highway at the Mawa-Janjira site have not been detected. It is assessed that any negative impacts will be able to be minimized through the appropriate mitigation measures, irrespective of routing.

(6) Public Utilities and Railways

It is considered that power lines of 400 KV, gas pipelines, and communication lines are accommodated on the Padma Bridge. Those public utilities require the connecting lines and some relay facilities on the both banks. But those are loaded only on the main bridge section, and the connecting portion will have their own geometry, independent of the Project highway, immediately beyond the end of the bridge on the both banks. Therefore, the routing of the Project highway is not essentially affected by the loading of public utilities.

In some cases in the Study, loading of the broad-gauge, single-track railway on the main bridge section may be also considered. Since railways generally require a higher standard of geometry than highways, some additional requirements must be considered in the geometric design of the Project highway in this case. However, even if it is loaded, the railway accommodation is also on the main bridge only, and any official railway construction program does not exist presently on the both sides of the Padma Bridge. Accordingly, it is also supposed that the railway will take its own geometry beyond a duly distant point from the bridge end on the both banks. Thus, in overall routing of the Project highway, much attention does not have to be paid to the railway accommodation, because additional requirements can be met in the process of geometric design of the Project highway and structural design of the main bridge.

(7) Overall Description of Selected Route

The Project Highway starts at Mawa on the existing at-grade intersection of NH8 and the existing Regional Highway R812 which runs eastward to connect to Tongibari through Lohajang. The distance from the riverbank to the project starting point is about 300 m, and the proposed approach road connects within this interval to the Padma Bridge.

There are houses in Mawa town with some degree of density. Therefore, an influence range is quite restrictive because of the occupation of proposed extension of approach road is quite limited for minimal social impact.

Where the Project Highway reaches a riverbank on the side of Janjira, it turns to the almost right angle direction of the upper stream and runs along the South Channel up to the Project ending point which connects to the existing NH8.

The distance of the whole project Highway is 17.743 km, which composes 0.213 km of the approach road at the Mawa side, 5.580 km of the Main Bridge, and 11.950 km of the approach road at the Janjira side.

On the side of Janjira, it intersects with six inland rivers and 14 existing roads (under RHD and LGED). The basic proposed height of the approach road is 8.85PwD which added 1.5 m to DHWL, 7.35PwD (= 3.04 m from SHWL). The Project Highway connects at Mawa and Janjira to NH8 finished level, by the ADB rehabilitation project, of 8.02PwD and 7.80PwD, respectively. Figure 9.9.2 shows the General Layout of Project Highway.

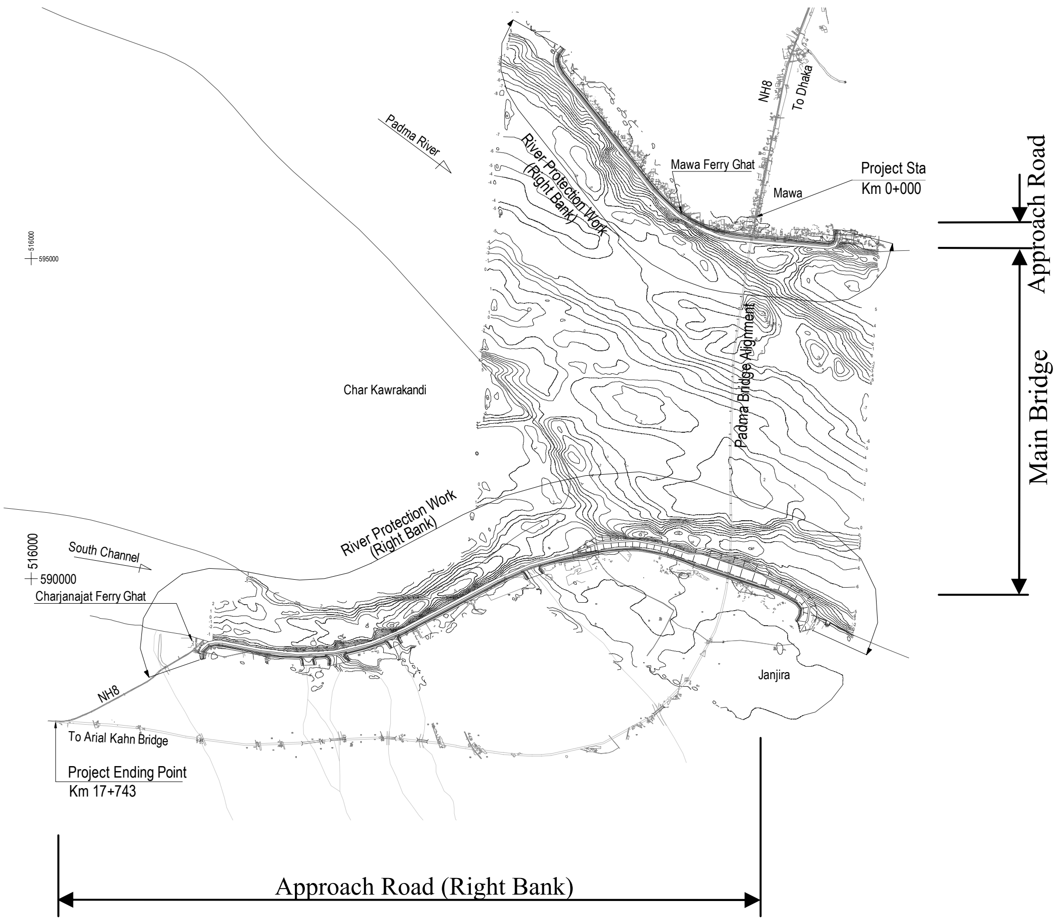


Figure 9.9.2 General Layout of Project Highway

9.9.2 Horizontal Alignment

The Project highway is planned over an extremely mighty river and in the adjacent flat flood plain with mostly agricultural land use. The basic policy for the horizontal alignment is to have a combination of straight lines, circular curves and transition curves with sufficiently mild and continuous geometry between the starting and ending points as determined as described above. As the route directions at the starting and ending points of the Project highway form almost a right angle, a large, long circular curve with the intersecting angle of about 80 degrees and the radius of 3,000 m, which is the smallest of the radii adopted to the entire Project highway, is set almost adjacent to the end of the main bridge in the plain on the right river bank, and a series of very mild curves and minimal straight lines are extended outward for both sides from this large circular curve.

The horizontal alignment components adopted are listed in the Table 9.9.1, and the resulting geometry is shown in Figure 9.9.3.

Table 9.9.1 List of Horizontal Alignment Adopted

Location	Section Distance	Cumulative Distance	Alignment Component	Remarks
Starting Point	0	0.000	R=∞	End point of N8, Center of Intersection
Left River Bank	213	213.000	R=∞	Abutment 1
	110	323.000	R=∞	Left river bank line
Sub-total	323.00	(0.323km)		**Approach Road Length=0.213km**
River	133.31	456.310	R=∞	
	3448.97	3905.280	R=15000	
	1717.72	5623.000	A=2955	Right river bank line
Sub-total	5300.00	(River=5.300km)		**Bridge Length=5.580km**
Right River Bank	170	5793.000	A=2955	Abutment 2
	1018.01	6811.010	A=2955	
	3193.59	10004.600	R=3000	
	1333.33	11337.930	A=2000	
	356.18	11694.110	R=∞	
	1709.72	13403.830	R=6000	
	363.04	13766.870	R=∞	
	1910.92	15677.790	R=6000	
	364.36	16042.150	R=∞	
	809.06	16851.210	R=6000	
Ending Point	892.17	17743.380	R=∞	Road Center of N8
Sub-total	12120.38	(12.120km)		**Approach Road Length=11.950km**
Total	17743.38	**(Project Length=17.743km)**		

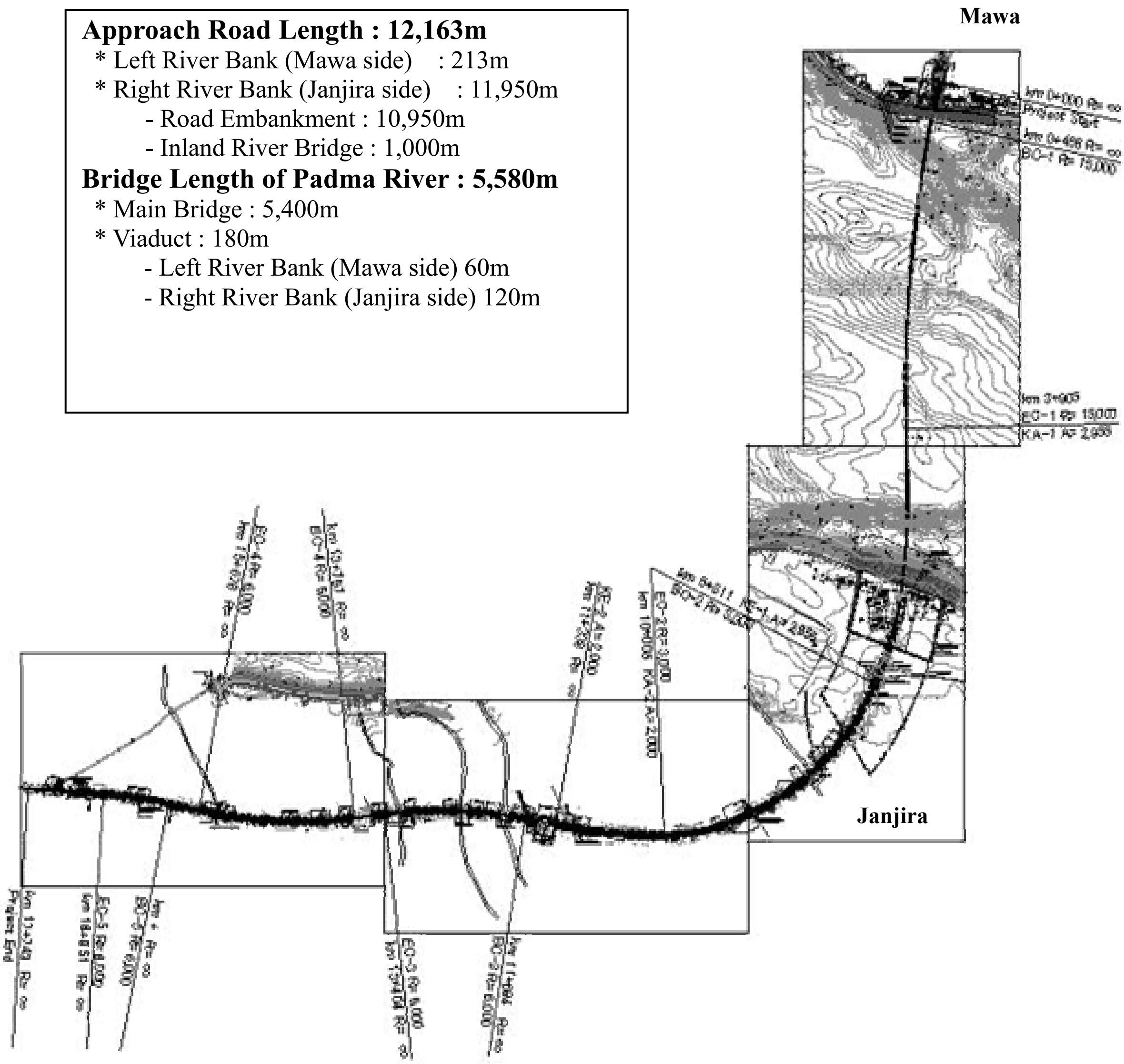


Figure 9.9.3 Horizontal Alignment of the Project Highway

9.9.3 Vertical Alignment

The premise for the design of the vertical alignment is to secure the required vertical clearance over the Standard High Water Level (SHWL) of the navigational channel in the Padma River, and to keep an adequate height of the surface of the approach road over the SHWL, because much of the flood plain is regularly inundated during the rainy season.

Through the negotiations with the Bangladesh Inland Water Transport Authority (BIWTA), it has been confirmed that the navigational requirements for the Padma Bridge, as shown in Figure 9.9.4, are;

- Width of the navigable course at the planned bridge site: 4.8 km
  (Actual width of the river at the same site:5.3 km)
- Navigational clearance required for each channel between the adjacent piers
  Horizontal: min. 250 ft.
  Vertical: min. 60 ft. for at least one span, or preferably three spans
  min. 40 ft. for other spans

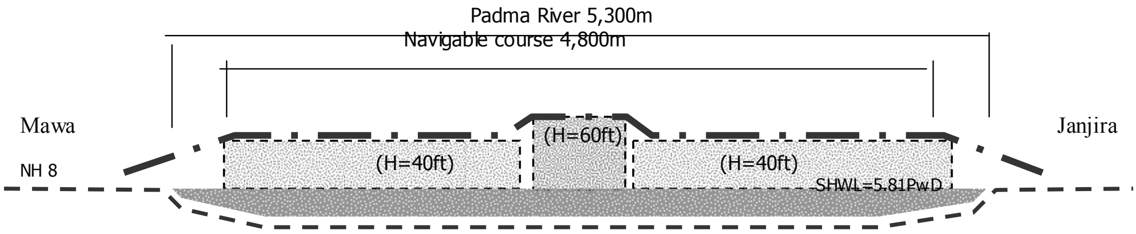


Figure 9.9.4 Navigational Requirement for Padma Bridge

Since the SHWL at the main bridge location is 5.81m PWD, the minimum proposed heights for the principal sections of the Project highway are set as follows;

- Central three spans of the main bridge:
  5.81(SHWL) + 18.29(60 ft.) + 4.60(Girder Height) = 28.70 m PWD
- Other spans of the main bridge:
  5.81(SHWL) + 12.19(40 ft.) + 4.60(Girder Height) = 22.60 m PWD
- Approach road:
  5.81(SHWL) + 3.04(DHWL+1.50) = 8.85 m PWD

These principal sections are inter-connected by slopes of less than or equal to 3% mostly, but 4% at maximum, and vertical curves of the adequate radius. The limit of the transition slope is strengthened to 1% in the section where the railway is supposed to be jointly loaded on the same superstructure with the highway, in case the railway loading is taken into account.

Where the approach road on the right river bank crosses waterways or local roads with a minor bridge or a culvert, some up-and-downs of the proposed height are designed, depending upon the required clearance for these structures.

The basic vertical alignment of the Project highway is shown in Figure 9.9.5 and Figure 9.9.6.

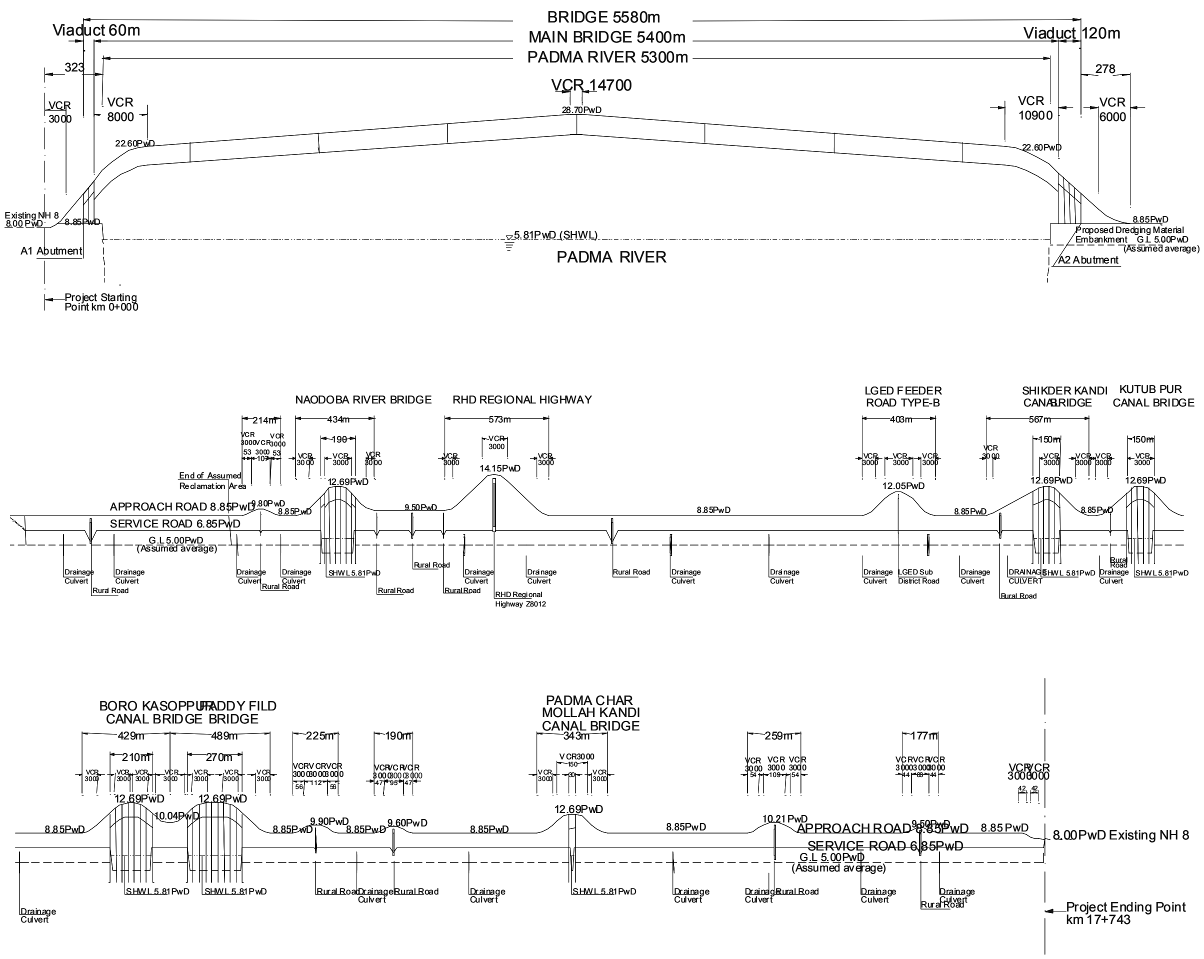


Figure 9.9.5 General View of Vertical Alignment

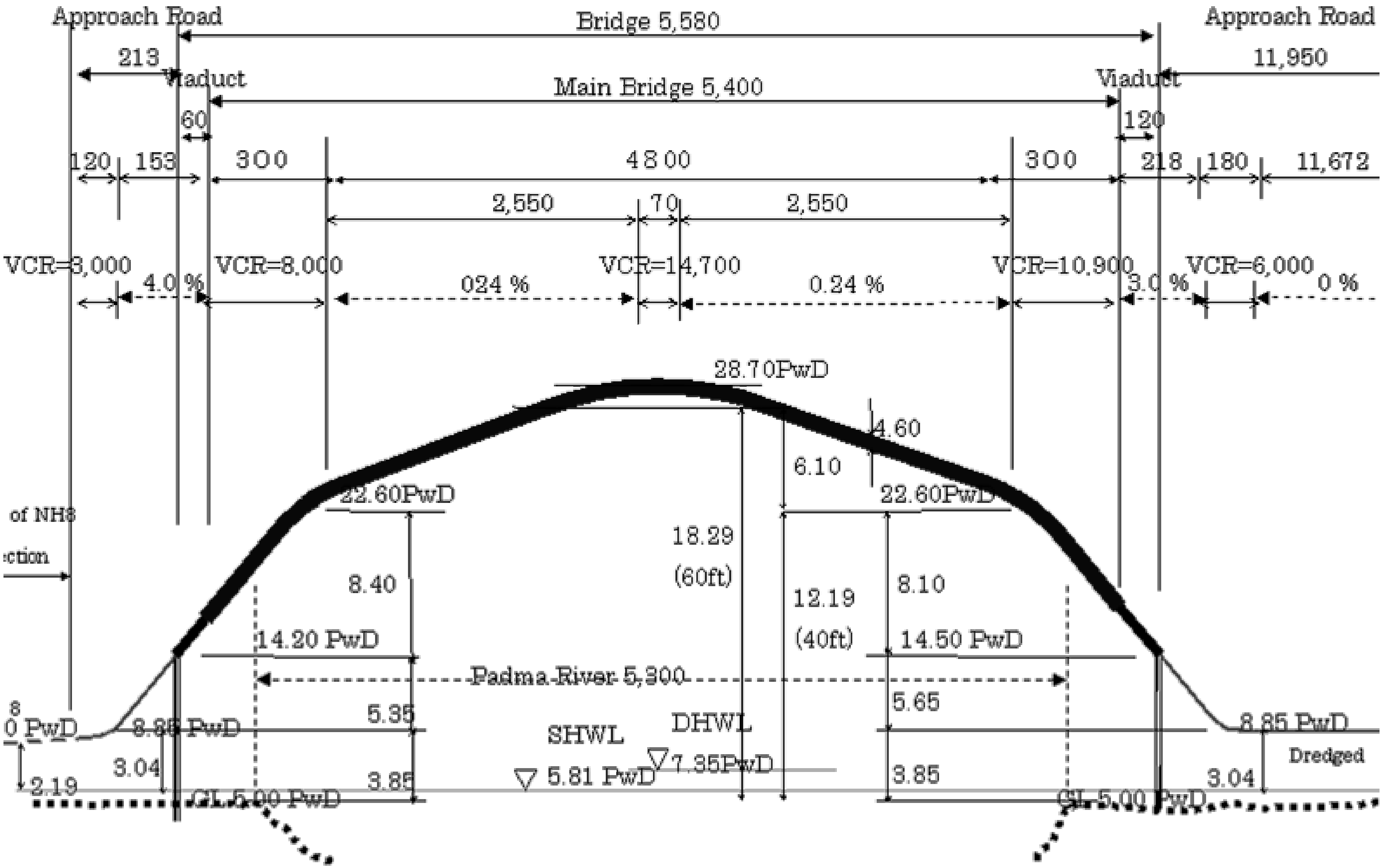


Figure 9-9-6 Basic Vertical Alignment of Padma Bridge Portion

9.9.4 Cross Section

As shown in Table 9.8.2, the typical cross section has considerable difference between the Asian Highway (AH) and RHD standards. The effective total width is specified as 24.0 m by the AH standard, while 19.8 m by RHD. Since this difference results mainly from the width of the median, i.e. 4.0 m vs. 1.6 m, the total of the carriageway and the shoulder has as little difference as 0.9 m in one direction, i.e. 10.0 m vs. 9.1 m. Moreover, the AH standard notes that the width of the median may be reduced by the proper guard fence, and also that each national standards should be applied to the design of structures such as bridges.

Hence, it is judged that even though the primary emphasis is put on the AH standard which generally has higher quality requirement, the typical cross section of the Project highway was initially determined separately for cases of the main bridge with and without the railway loading, respectively, and the approach road.

Thus, the basic policy for the cross section has been concluded as follows:

- Main bridge without railway loading, though abandoned in the end:
  AH substandard with reduced median width, almost similar to RHD standard
- Main bridge with railway loading, adopted in the end:
  AH standard with staged minor modification
- Approach road:
  AH standard

The typical cross sections for these cases are shown in Figure 9.9.7 through Figure 9.9.9

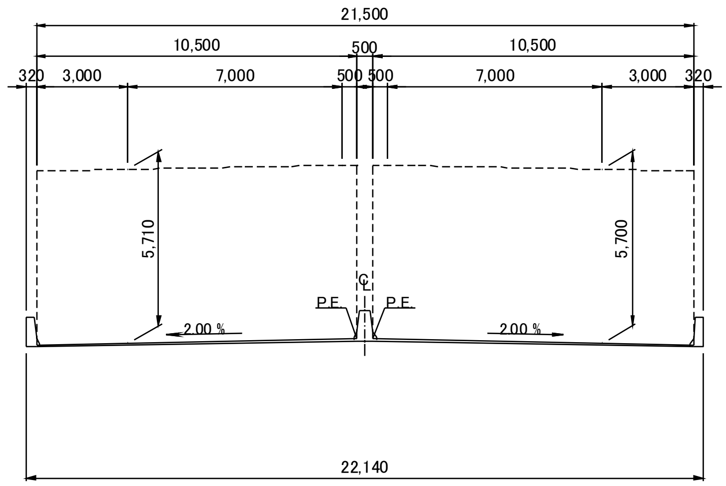
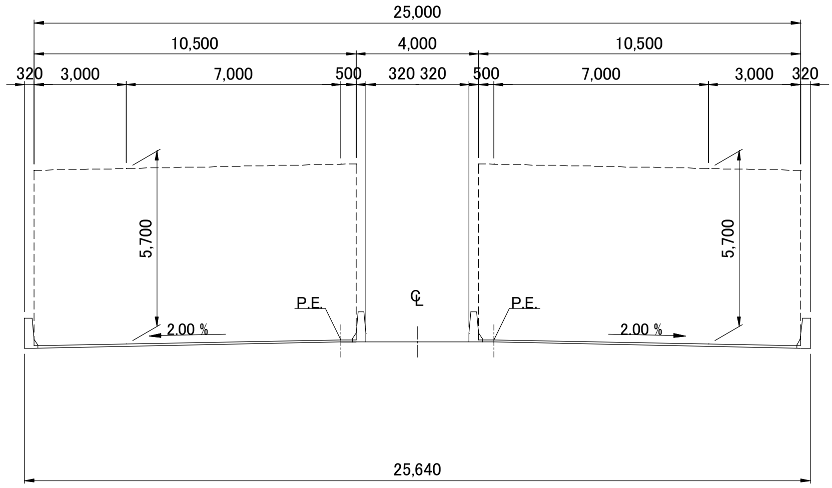
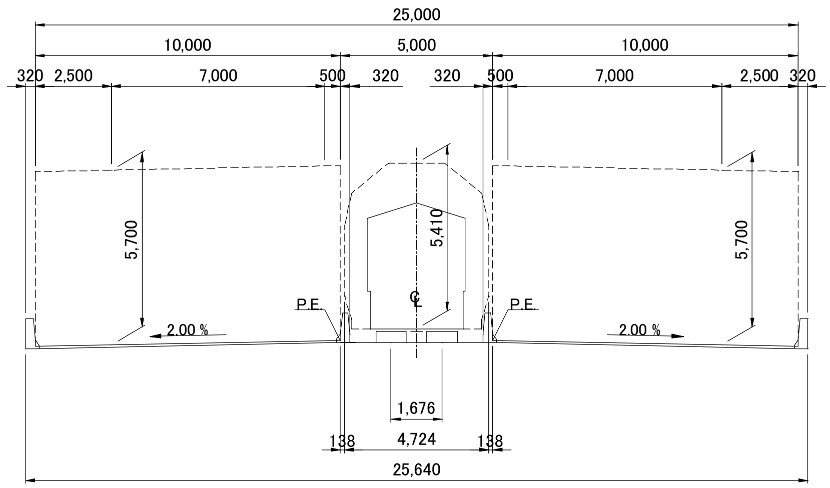


Figure 9.9.7 Typical Cross Section for Main Bridge without Railway Loading



A. Initial Stage



B. Final Stage

Figure 9.9.8 Typical Cross Section for Main Bridge with Future Railway Loading

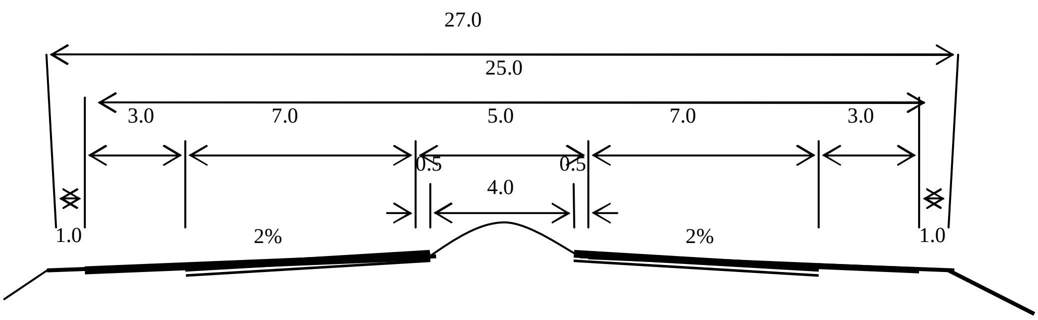


Figure 9.9.9 Typical Cross Section for Approach Road

9.10 PRELIMINARY DESIGN OF APPROACH ROAD

9.10.1 Embankment

The Project highway in total length of 17.743 km consists of;

- 5,400 m long main bridge,
- 180 m long connecting viaducts on the both river banks (60 m at left and 120 m at right banks), and
- 12,163 m long approach roads on the both river banks (213 m at left and 11,950 m at right banks).

The approach road is an embankment, in structure, with the basic proposed height of 8.85 m PWD (3.04 m above SHWL) at the right bank. However, at a number of locations where it crosses local roads and waterways, the approach road is required to have a higher elevation than the basic proposed height so as to ensure the required minimal clearance for the minor structure for the crossing road or waterway, consequently leading to the profile with intermittent rise-and-falls over the basic proposed height.

As for the cross section, the embankment has the crest width of 27.0 m, the slope gradient of 1:3 at the both sides, the typical crossfall of the road surface of 2%, and the total right-of-way width of 100 m as shown in Figure 9.10.1.

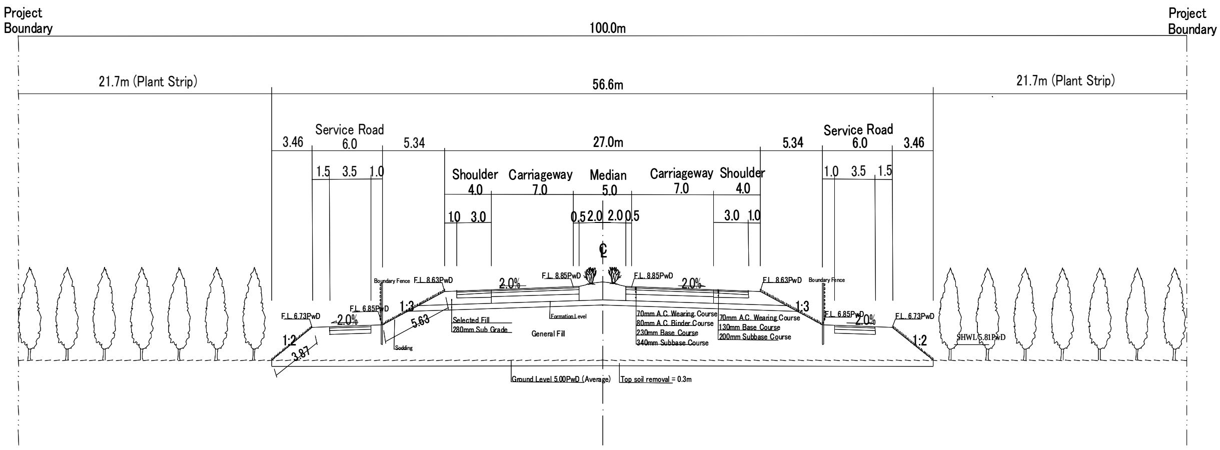


Figure 9.10.1 Typical Cross Section of Embankment

The available earthwork material from the side borrow is predominantly fine sand with variable amounts of silt and some clay. But the earth to be dredged in a massive amount from the river training work of the Project is expected to have lower silt contents, and should be effectively utilized for embankment. Though adequacy of the foundation soil will be verified by its bearing capacity, slope stability, settlement characters and suitability for embankment, foundation soil may comprise extensive deposits of clayey silt. Since the approach road is located in the inevitably inundated area during the rainy season, the foot of the embankment slope should be adequately protected against erosion.

As the longitudinal gradient on the approach road is basically 0% (level), except for the intermittent rise-and –falls over the crossing road or waterway, the surface water on the approach road can be catered by direct transverse run-off along the crossfall of the pavement and the slope of the embankment. As the ground along the approach road has generally no distinct topographic gradient in any direction, either, the longitudinal drainage is required neither at the edge of the pavement nor at the foot of the embankment.

9.10.2 Service Roads

Lest the fully access-controlled Project highway should cause local people inconvenience by hindering the function of the crossing local roads, the service road is planned at the both sides along the approach road, leading the crossing local traffic to the nearest underpass to be provided for a crossing local road or trail. The cross section of the service road is typically as shown in Figure 9.10.2, with a total width of 6 m. The basic formation level of the service road is set to be 2 m lower than that of the approach road of the Project highway (8.85 – 2.0 = 6.85 m PWD), but it is adjusted, approaching an actual crossing local road, so as to be smoothly connected to it. For the drainage purpose the service road is designed to have a transverse, outward gradient of 2%.

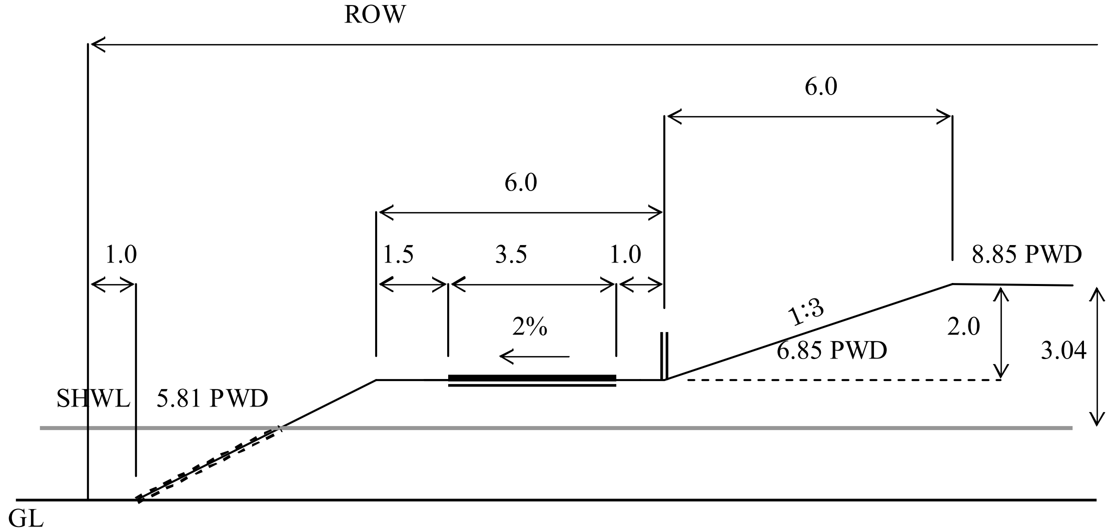


Figure 9.10.2 Typical Cross Section for Service Road

9.10.3 Pavement

The Study has provided the traffic forecast for the target years, 2015 and 2025, for the Project highway in the previous report, which is re-tabulated as follows;

Table 9.10.1 Traffic Demand Forecast for Project Highway, ADT

	2015		2025	
	vehicles a day	%	vehicles a day	%
Light Vehicle	3,850	18.1	7,340	17.7
Bus	13,210	62.1	26,750	64.4
Truck	4,200	19.8	7,460	18.0
Total	21,260	100.0	41,550	100.0

The pavement design by the AASHTO method for the approach road of the Project highway is conducted under the conditions as shown in Table 9.10.2, the essence of which is derived from the above traffic data and 1990 Road Master Plan, ADB, and the design traffic load per lane (ESAL) is calculated accordingly.

Table 9.10.2 Pavement Design Conditions

Parameters	Conditions
1) Design Period	10 Years（2015-2025）
2) Design Traffic Volume	122.03 million. vehicles in 10 years
3) Traffic Composition	Truck 18.9%, Bus 63.3%
4) Design Axle Load	Truck(2Axle) 8.42ton、Bus (2Axle) 6.85ton
5) Lane Distribution	120%
6) Design Load（ESAL）	38.02 million. ESAL / Lane
7) Pavement Material	* Asphalt Concrete: 5cm Wearing Course + 10cm Binder Course * Base: Crushed stone base (CBR 80 equivalent) * Subbase: Glandular material (CBR 30 equivalent) * Subgrade: Selected material (CBR 8, assumed)

The pavement design resulted in the total thickness of 72 cm with each layer as shown in Table 9.10.3, and the typical cross sections, as shown in Figure 9.10.3.

For the pavement on the ramps, the same composition and thickness as the carriageway will be applied, while the service road will have the minimally required pavement composition, as shown in Figure 9.10.4.

Table 9.10.3 Pavement Design Outcomes

Design Pavement Thickness	A.C. Wearing Course: 7 cm A.C. Binder Course: 8 cm Base Course: 23 cm Sub Base Course: 34 cm Total; 72 cm

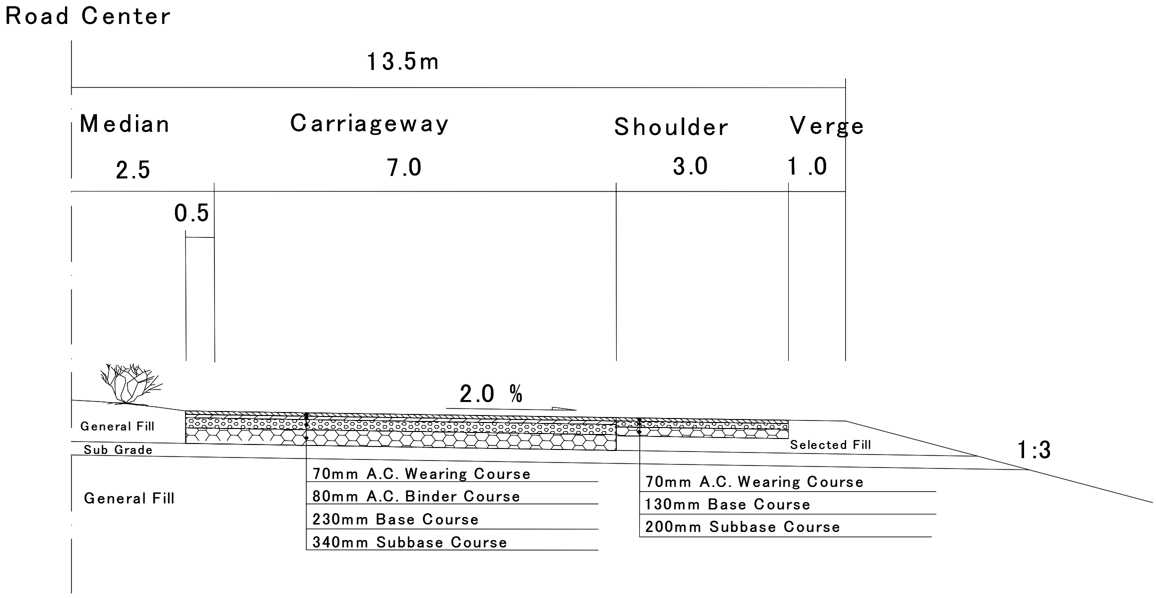


Figure 9.10.3 Typical Cross Section for Pavement of Embankment Carriageway

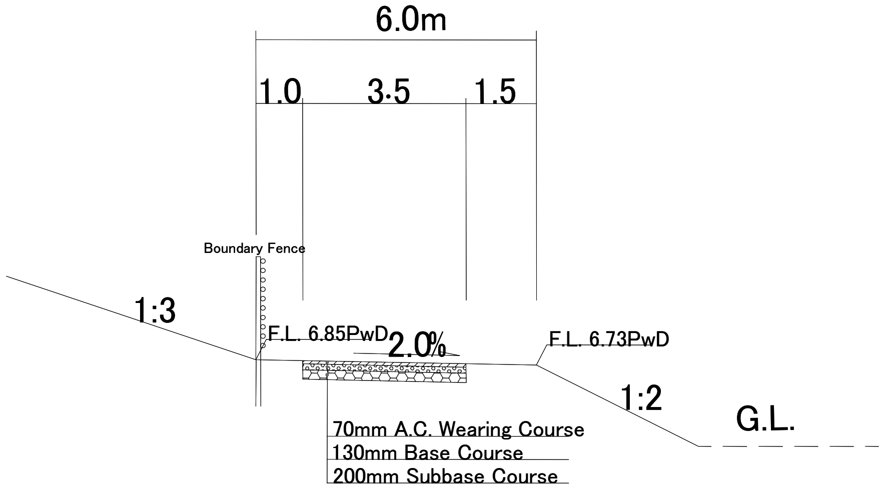


Figure 9.10.4 Typical Cross Section for Pavement of Service Road

9.10.4 Minor Structures

(1) General View of Approach Road

The approach road of the Project Highway will have some minor transverse structures at locations crossing inland waterways or existing local roads, or requiring facilities for ground water drainage. The general feature of the approach road with these transverse structures, as well as the embankment, the service road, and the slope protection, in the right-of –way range is as shown in Figure 9.10.5.

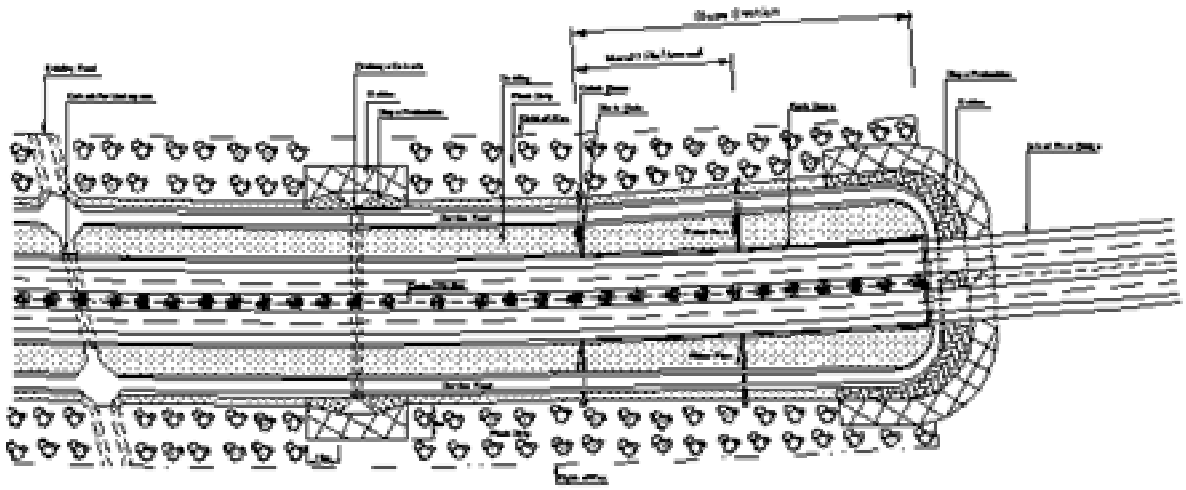


Figure 9.10.5 General View of Approach Road

(2) Bridges on Approach Road

On the right bank of the Padma River, the Project highway crosses five minor inland waterways and one paddy field, which are supposed to be used usually as local navigational channels during most of the period of the year. Through the negotiations with the authority in charge, BIWTA, it was concluded that the required navigational clearance for these waterways is horizontally 20 m and vertically 5 m above the water level equal to the SHWL of the Padma River (5.81 m PWD), as shown in Figure 9.10.6, except for one waterway located nearest to the ending point of the Project highway, for which the minimum vertical clearance requirement is no more than 2 m. Those bridges are planned to be single- or multi-spanned with a combination of 20 m and 30 m span lengths, as listed as in Table

9.10.4 and typically shown in Figure 9.10.7.

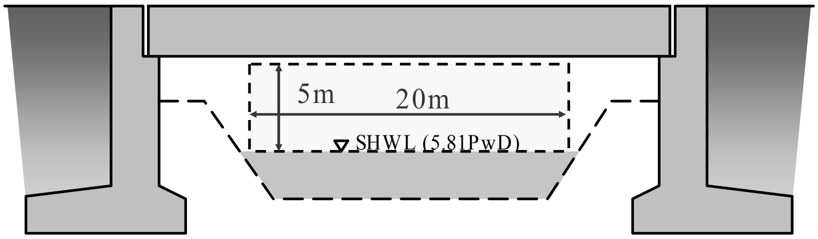


Figure 9.10.6 Required Navigational Clearance for Inland Waterway

Table 9.10.4 List of Bridges over Minor Waterways

No.	River/Canal (Khal) Name	Location (km)		Span Nos.		Bridge Length (m)	Crossing Angle (°)
		@ A1	@ A2	20m span	30m span		
1	Naodoba River	7+958	8+148	2	5	190	90
2	Shikder Kandi Khal	11+873	12+023	0	5	150	"
3	Kutub Pur Khal	12+388	12+538	0	5	150	"
4	Boro Kasoppur Khal	13+163	13+373	0	7	210	"
5	(Paddy Field)	13+543	13+813	0	9	270	"
6	Padma Char Mollah Kandi Khal	15+413	15+443	0	1	30	60

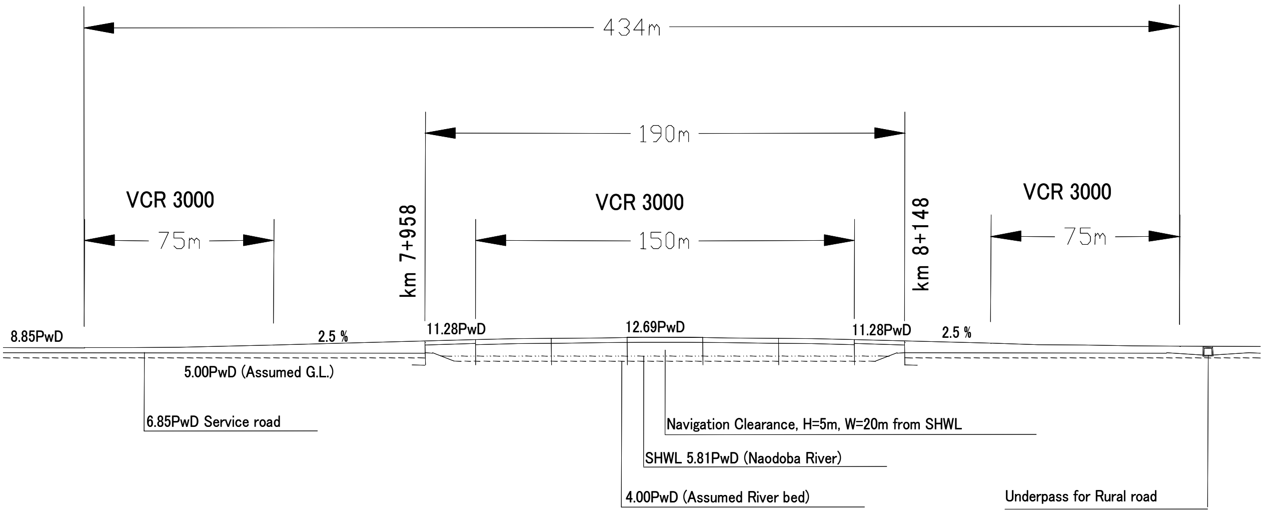


Figure 9.10.7 Typical Profile for Inland Waterway Bridge

(3) Box Culverts

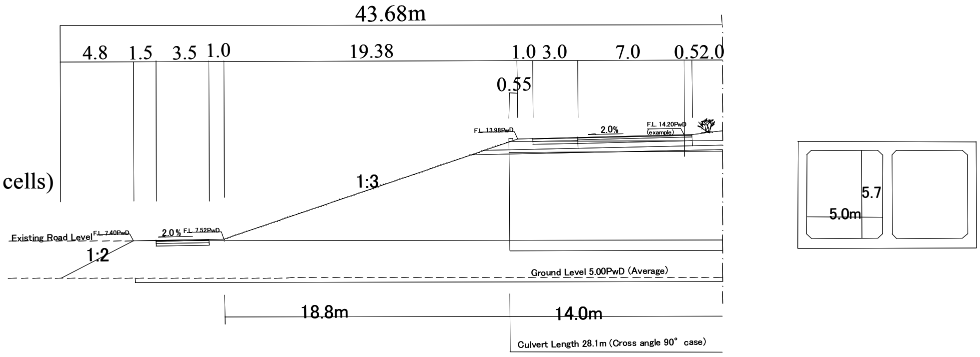
Where the Project highway crosses the local roads, the crossing roads are planned to be provided with an underpass in the box culvert type. The dimension and the proposed elevation of the underpasses for each road were determined through the negotiation and agreement with RHD and LGED, based on the categorization and specification as shown in Figure 9.10.3.

Thus, the proposed box culverts to be provided for underpasses for crossing roads are as shown in Table 9.10.5 and Figure 9.10.8.

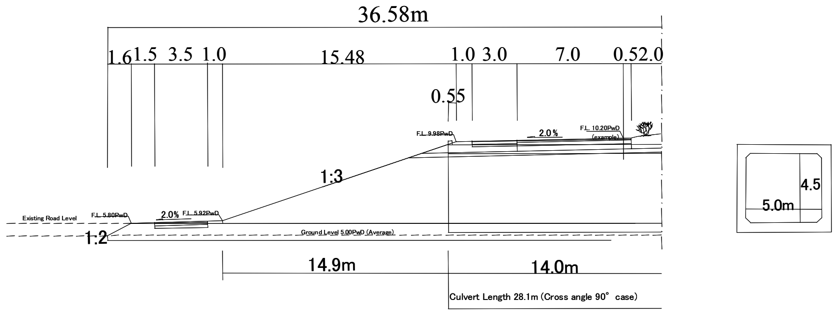
Table 9.10.5 List of Proposed Underpasses

No.	Road Classification	Culvert Type (HxW)	Location (km)	Number of Cell	Culvert Length (m)	Crossing Angle (°)
1	Rural Road	D (2.5x3.0)	6+700	1	28.5	80
2	Rural Road	D (2.5x3.0)	7+620	1	29.2	75
3	Rural Road	D (2.5x3.0)	8+273	1	29.0	"
4	Rural Road	D (2.5x3.0)	8+467	1	29.1	"
5	Rural Road	D (2.5x3.0)	8+630	1	30.8	50
6	Regional Highway	A (5.7x2@5.0)	8+916	2	29.2	73
7	Rural Road	D (2.5x3.0)	9+400	1	38.8	45
8	Sub-District Road	B (4.5x5.0)	11+132	1	36.6	50
9	Rural Road	D (2.5x3.0)	11+692	1	32.5	60
10	Rural Road	D (2.5x3.0)	12+302	1	29.2	75
11	Rural Road	D (2.5x3.0)	14+182	1	28.2	85
12	Rural Road	D (2.5x3.0)	14+560	1	28.5	80
13	Rural Road (paved)	C (3.5x4.0)	16+417	1	31.6	63
14	Rural Road	D (2.5x3.0)	17+131	1	29.2	74
				Total=	431	m

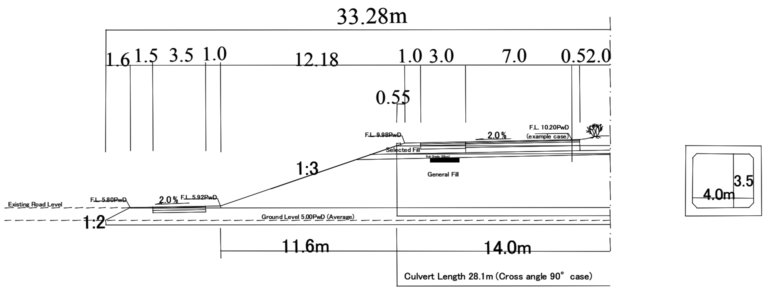
Type-A
(H=5.7, W=5.0m x 2 cells)



Type-B
(H=4.5, W=5.0m)



Type-C
(H=3.5, W=4.0m)



Type-D
(H=2.5, W=3.0m)

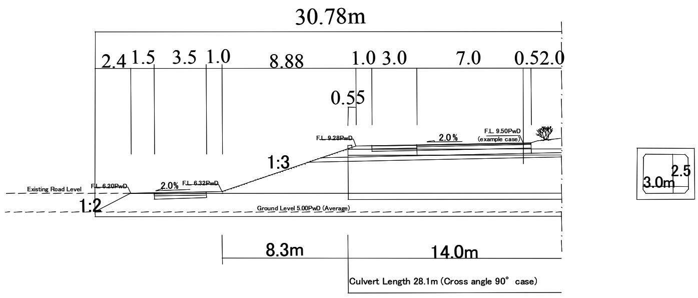


Figure 9.10.8 Structural View of Underpass for LGED Roads

(4) Drainage Culvert

Since the approach road crosses the flood plain, the transverse culverts are required at the potential water stagnant locations for ground water drainage. The list and typical profile of proposed box culverts are as shown in Table 9.10.6 and Figure 9.10.4, respectively.

Table 9.10.6 List of Drainage Culverts

No.	Culvert Type (HxW)	Number of Cell	Location (km)	Culvert Length (m)	Crossing Angle (°)
1	Box (2.0x3.0m)	1	6+547	51.0	90
2	Box (2.0x3.0m)	1	6+824	51.0	〃
3	Box (2.0x3.0m)	1	7+500	51.0	〃
4	Box (2.0x3.0m)	1	7+738	51.0	〃
5	Box (2.0x3.0m)	1	8+386	51.0	90
6	Box (2.0x3.0m)	1	8+748	81.1	50
7	Box (2.0x3.0m)	1	9+088	63.0	90
8	Box (2.0x3.0m)	3	9+884	51.0	〃
9	Box (2.0x3.0m)	1	10+423	52.8	75
10	Box (2.0x3.0m)	3	11+307	57.3	70
11	Box (2.0x3.0m)	1	12+770	50.9	80
12	Box (2.0x3.0m)	1	14+372	51.8	80
13	Box (2.0x3.0m)	1	14+922	52.8	75
14	Box (2.0x3.0m)	1	15+922	54.4	70
15	Box (2.0x3.0m)	1	16+839	52.9	75
16	Box (2.0x3.0m)	1	17+227	52.9	75
			Total=	1,092	m

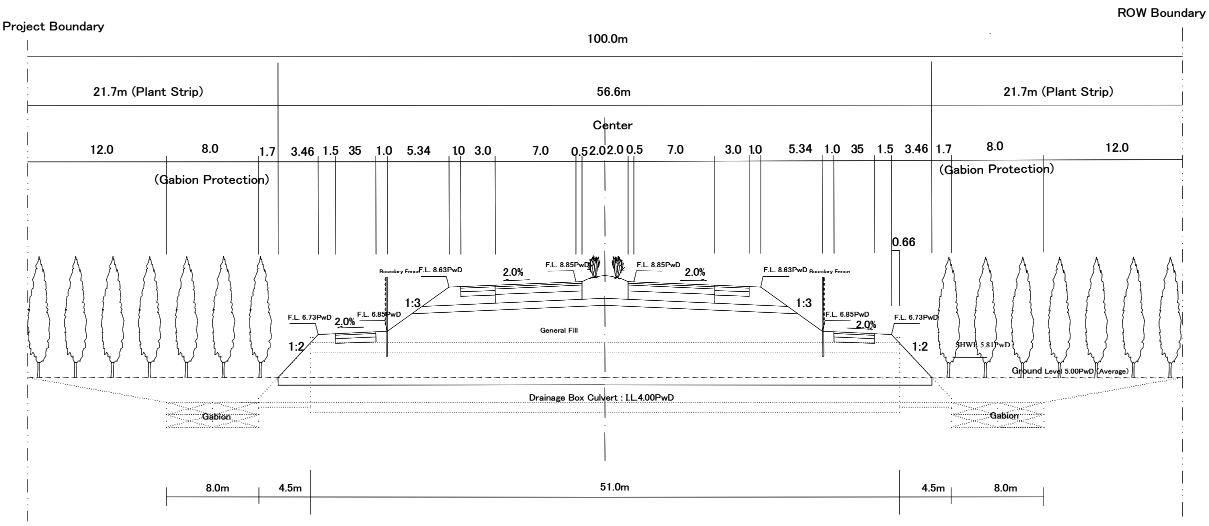


Figure 9.10.9 Typical Profile of Drainage Culvert

9.11 ASSOCIATED FACILITY PLAN

9.11.1 Toll Gate

As repeatedly stated, once it is constructed, the Project highway will be certainly operated as a toll road. Then, a plan for the toll facilities including the toll gate with a set of the islands, booths and the roof, the toll office, and the toll plaza should be set up in the preliminary design.

Since the Project highway is not a network type toll road, but one of the stand-alone type with a single toll section, the simplest toll system with a flat toll rate by vehicle class, having only a single, barrier-type, toll gate in each direction of traffic, is adequate. It is generally required that the toll plaza be located in the section with a horizontal alignment of the straight line, desirably, or as mild a curve as possible, and a vertical gradient of less than 2%. Due to lack of a proper space on the left river bank, and complying with this requirement, the location of the toll gate has been determined at around km 11+500 on the right river bank jointly for the both directions of traffic, as shown in Figure 9.11.5.

The required number of lanes in one direction at the toll gate is theoretically dependent upon the incoming traffic volume (i.e. the average interval of arriving vehicles) and the average service time at the gate for the required service level (the average number of waiting vehicles per lane). Usually, the design hourly traffic volume for the target year (vehicles per hour) and the empirically known average service time for each toll collection type (seconds per vehicle) are used to obtain the required number of lanes for the target service level (vehicles per lane). If the vehicle arriving intervals and the service times have the Poisson and exponential distributions, respectively, the number of lanes is computed as follows;

Table 9.11.1 Required Number of Lanes in One Direction at Toll Gate

Service Level =Average Queue Length (vehicles per lane)	Service Time (seconds per vehicle)	Design Hourly Traffic Volume (vehicles per hour)							
		1,440	1,620	1,800	1,980	2,160	2,340	2,520	2,700
1.0	6	4	4	4	4	5	5	5	6
	8	4	5	5	5	6	6	7	7
	14	7	7	8	9	10	10	11	12
3.0	6	3	3	4	4	4	5	5	5
	8	4	4	5	5	6	6	6	7
	14	6	7	8	8	9	10	11	11

For the Project highway, which is located in the rural area, the peak hour factor of 0.08 is multiplied to the forecasted ADT for 2025, 41,550 / 2 vehicles a day in one direction, and the design hourly volume is calculated as 1,662 vehicles an hour. The average service time for the flat toll rate system is empirically around 8.0 seconds per vehicle. Then, if the service level is set as the average queue length of 1.0 vehicle per lane, the required number of lanes in one direction at the toll gate results in 5 lanes.

Provided that the number of lanes is thus planned, the dimensions of the toll gate, as required by the Japanese standards, such as the width of the lane, the length, height and width of the island, the position of the booth and so on, are as shown in Figure 9.11.1.

Though at the roadside of the toll gate, a toll office, where the toll collection is administered, must be positioned, the operation and maintenance station for the entire Project highway, which is the site base of the toll road operator, should be jointly provided at the same location, because the Project highway is a single-section, stand-alone type toll road. The layout plan of the toll plaza and the adjacent operation and maintenance station is as shown in Figure 9.11.2.

Incidentally, the Study Team notes a claim from some Bangladeshi counterparts that the toll gate in each direction should be separately located in the vicinity of the directional entrance so as to physically prevent the users with no money to pay as a toll from using the toll road (i.e. crossing the Padma River). However, this claim is judged to originate from the perception of the present pre-maturity of the society, and the Study Team is very reluctant to accept it as a sole proposal for a plan of the associated facilities in the feasibility study on such a major future project as the Padma Bridge. Therefore, the directionally separate toll gate plan, which obliges the Study to alter significantly the approach road design on the left river bank, causing a shift upward of the starting point of the Project highway, an increase in the Project length by approximately 500 m, and re-alignment of the connecting NH8, the crossing Regional Highway R812 and the intersection between them, as shown in Figure 9.11.3, is also presented as an alternative option to the single toll gate location plan.

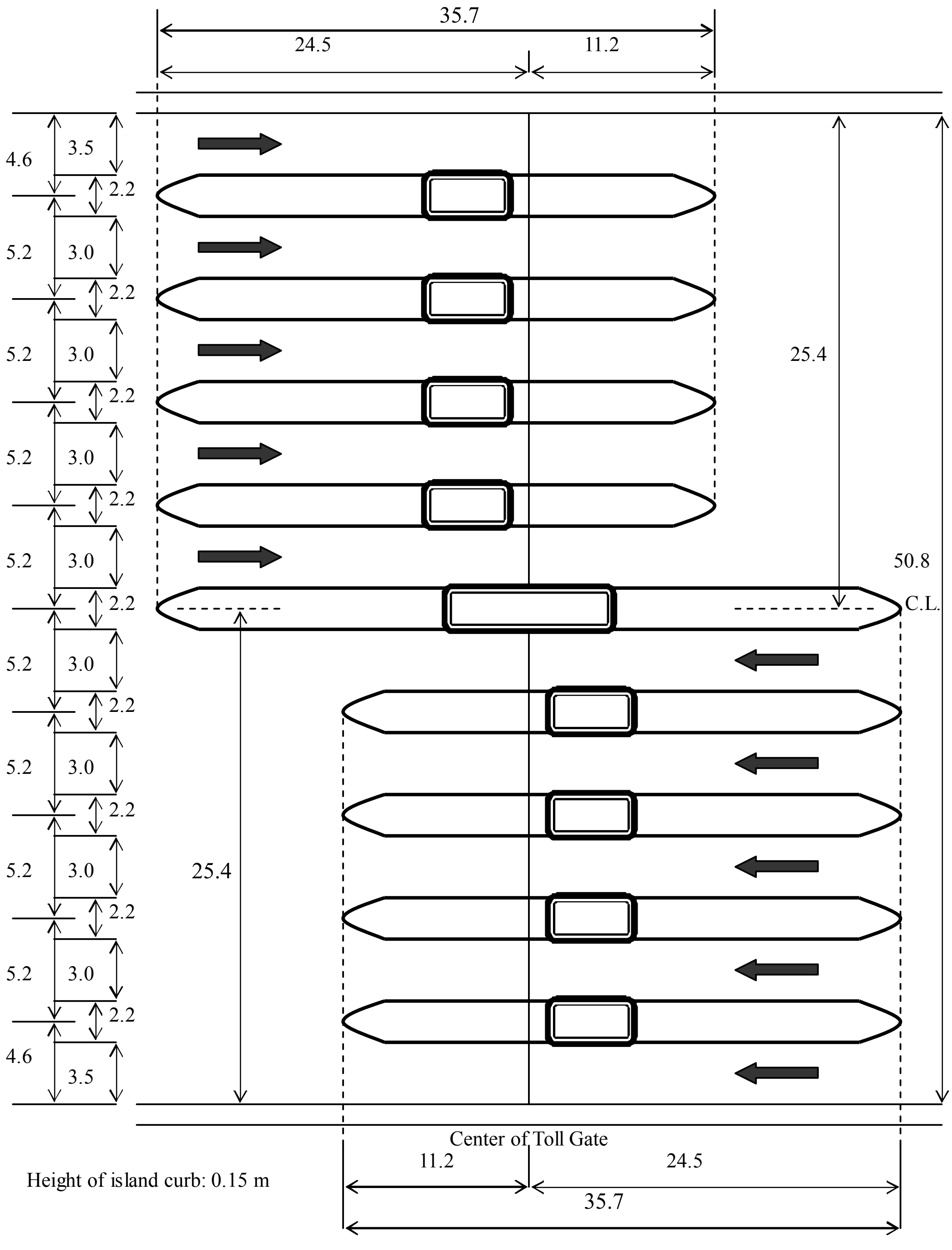


Figure 9.11.1 Typical Dimensions of Toll Gate

Figure 9.11.2 An Example Layout for Toll Plaza and O/M Station

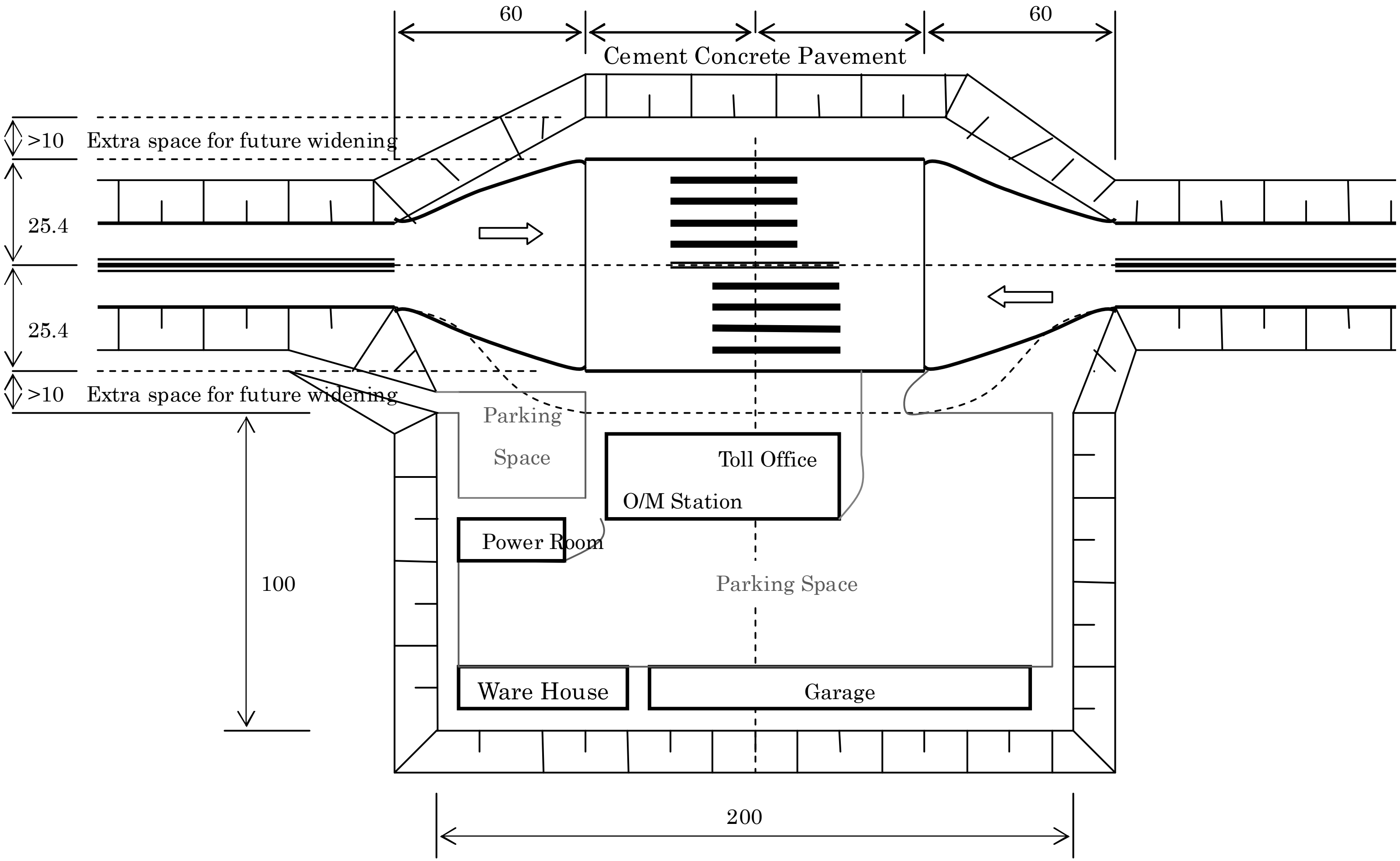
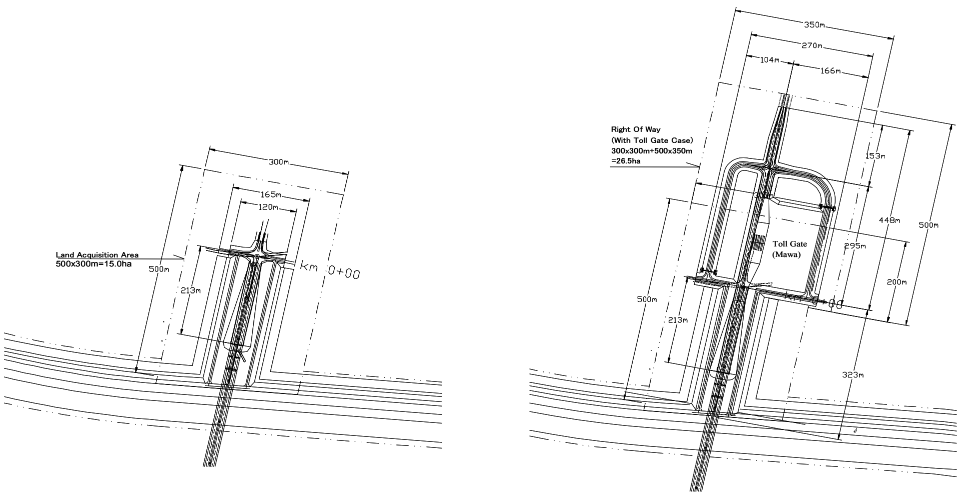


Figure 9-11-2 An Example Layout for Toll Plaza and O/M Station



(A) Proposed Joint Toll Gate Case (B) Alternative Directionally Separated Toll Gate Case

Figure 9.11.3 Comparison of Approach Road Shapes on Left River Bank

9.11.2 Service Area

Rest areas where drivers and passengers can take a rest, have a meal, adjust the travel time, or have the vehicle fueled/repaired are desirably needed on the inter-urban highways for use primarily for longer-distance travels, especially on the stopping/parking-prohibited, access-controlled ones. They are named the service area, the parking area, or the highway station, depending upon the size of the area, the facilities provided, or the operator authorized to provide the services. For the Project highway, let the rest area, if to be considered, be assumedly called the service area, because a variety of facilities could be proposed in various manners of provision in the area with such excellent landscape resources as the world-class major bridge over the world-class mighty river.

The location of the service area had better be selected near the river bank line of the Padma River, for the reason of the utilization of the Padma Bridge to be designed from an aesthetically sophisticated landscaping spirit over the 6 km wide Padma River as a tourism resource. Moreover, particularly the right bank should be selected for two reasons such as (1) the effective utilization of the reclaimed ground by the earth to be dredged massively from the river training work of the Project along the right river bank line, and (2) simply no space on the left bank where the approach road of the Project highway is too short to provide a service area.

The size of the service area, which is usually denoted by the parking capacity in terms of the number of painted parking lots, is to be determined by the anticipated parking demand, based on the traffic forecast (ADT) for the target year (typically 10 years after commissioning) and the estimated vehicle drop-in rate. However, as for the latter, the empirical tendency is absolutely impossible to obtain, because there has never existed any similar facility in Bangladesh. Therefore, the size of the Project service area is tentatively supposed to be “medium,” for which the parking capacity is around 150 lots in one traffic direction, according to the Japanese standard.

Besides the parking space, the facilities to compose a service area basically include the dining/store building, toilet, gas/repair station, and landscaped/plaza area, for which adequate layout should be considered making good use of the character of the location and, particularly, taking into account the availability of water supply and sewage means. Other facilities, such as the hotel, observatory, picnic area, sports area, amusement center, shopping center, culture center, and so on, could be provided, based upon the demand for them, the culture of the country, the local conditions of the location, the way of business implementation, or the type of financing for the facilities or the Project.

Among the two basic types of the service area, the separated for each of the two traffic directions and the united at either side of the highway for the both direction, the Project service area should obviously take the latter type, due to the above-mentioned character of the location and effective usage of the facilities provided.

Thus, the whole size of the service area will be determined primarily by those factors, but will it also be affected significantly by how and to what extent the required earth for the service area ground be secured ——— utilize just the readily available earth dredged from the river training work, or obtain some more earth from some borrow pit particularly for ground formation for the service area. Anyway, the elevation level of the service area should be equal to or higher than the basic proposed height of the approach road in the flood plain on the right river bank, 8.85 m PWD, which requires a considerable amount of earth depending upon the whole size of the service area.

An example plan of the service area is shown in Figure 9.11.4, and the facility plans (1) and (2) on the Project highway in Figure 9.11.5 for a single toll gate location case and in Figure 9.11.6 for the directionally separate toll gate case, respectively.

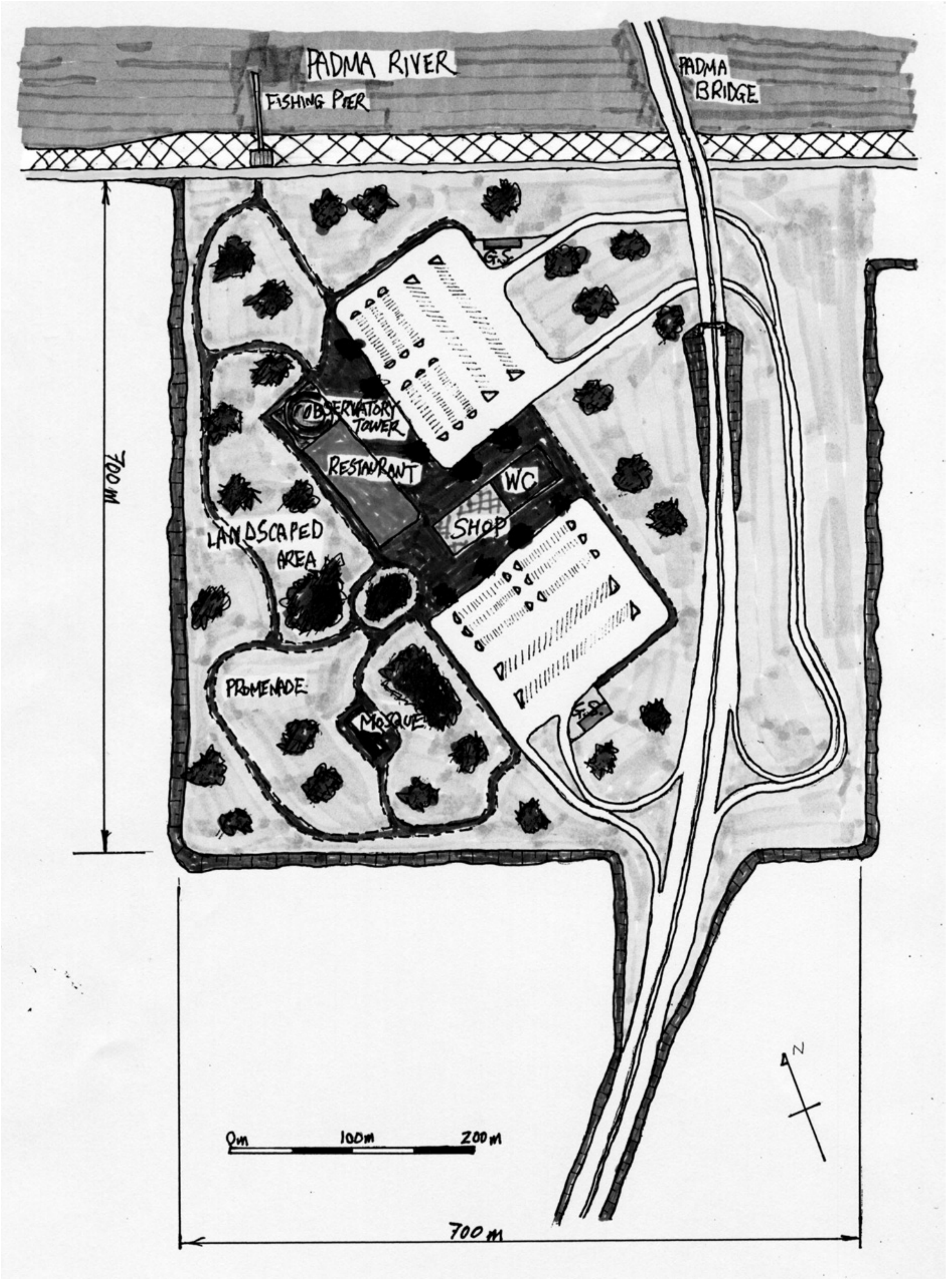


Figure 9.11.4 An Example Plan of Service Area

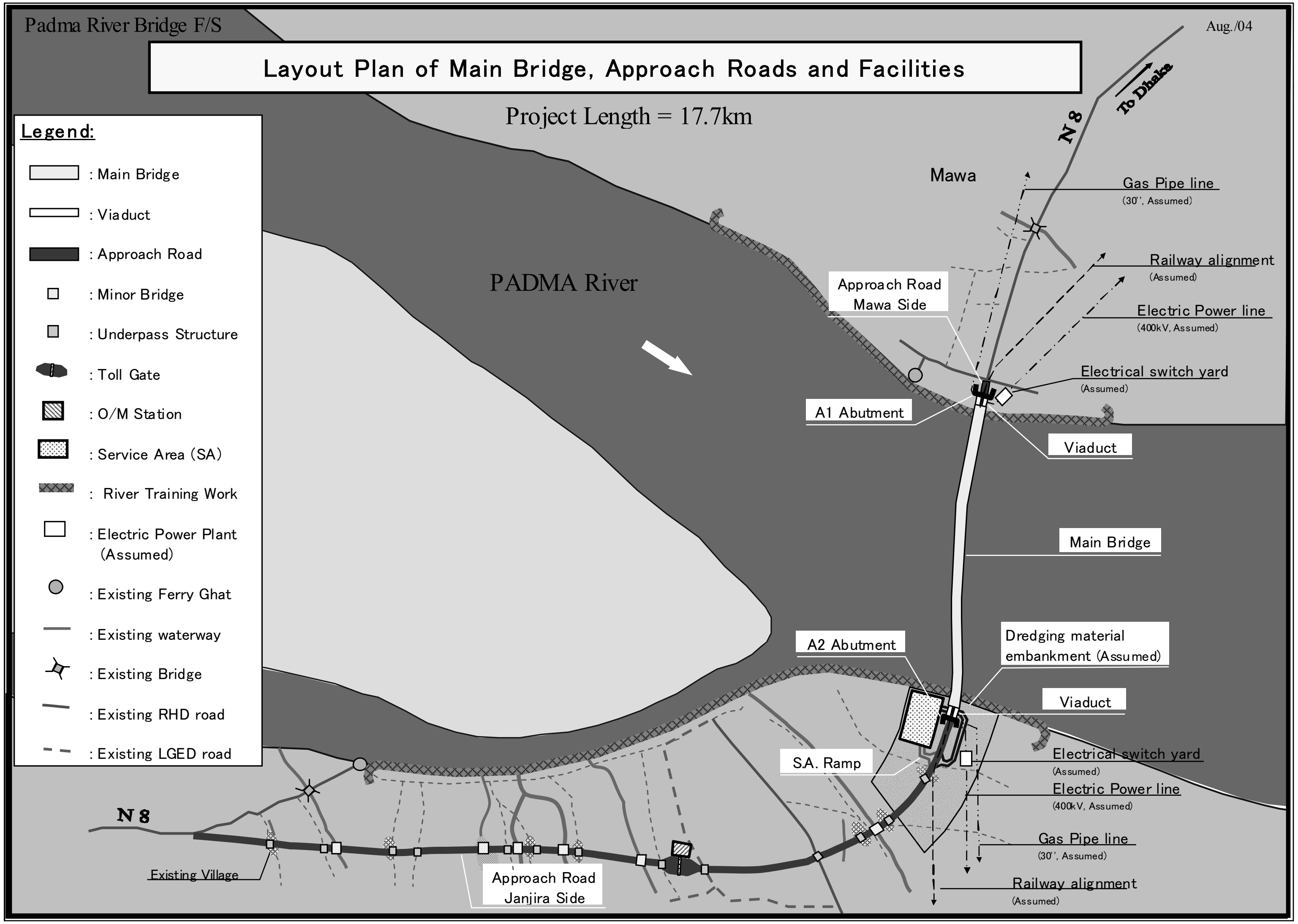


Figure 9-11-5 Layout Plan (1) for Facilities on Project Highway

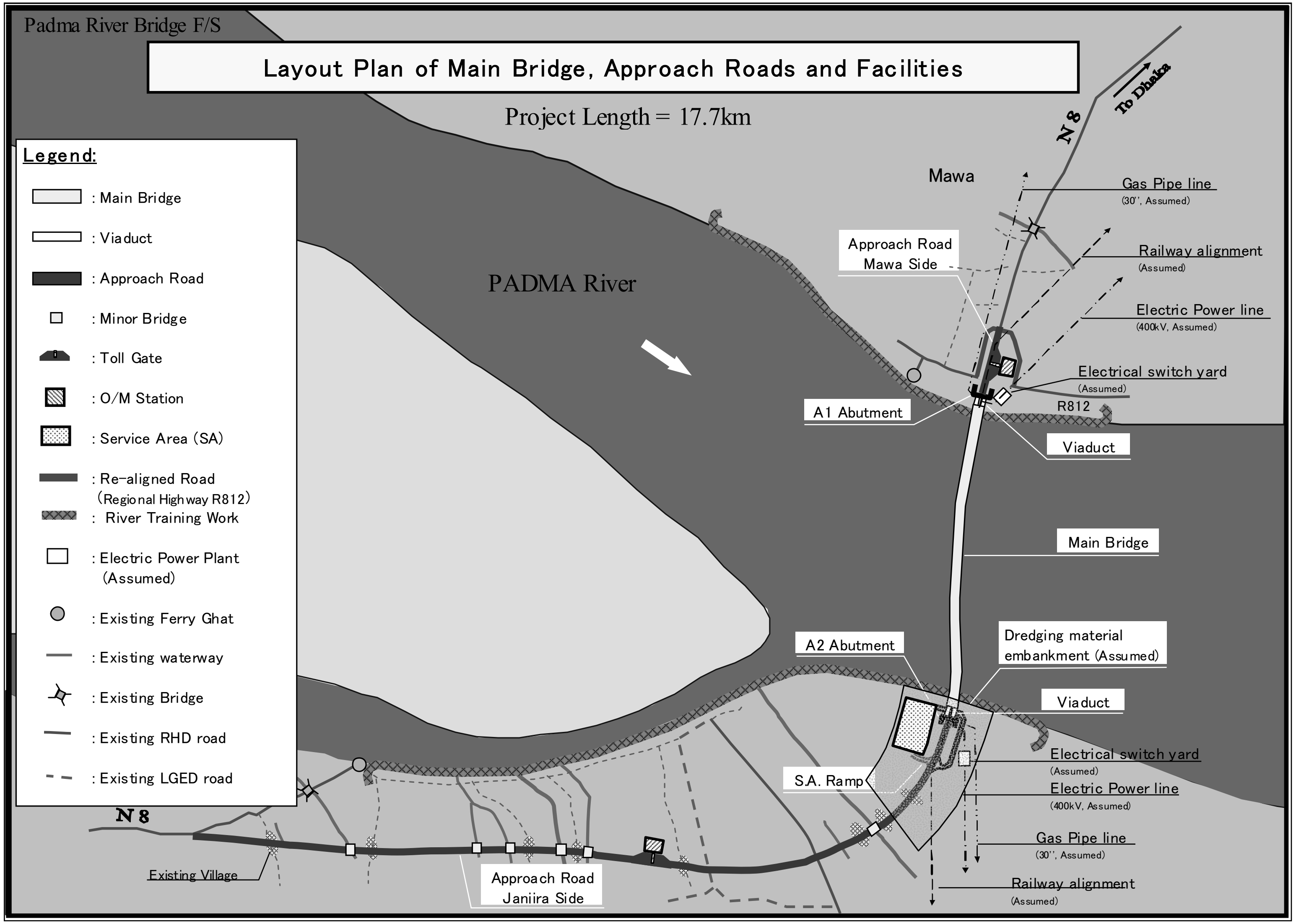


Figure 9-11-6 Layout Plan (2) for Facilities on Project Highway

9.12 QUANTITIES OF MAJOR WORK ITEMS FOR APPROACH ROAD AND ASSOCIATED FACILITIES

The indicative quantities of major work items obtained from the preliminary design of the approach road and associated facilities are as shown in Table 9.12.1.

Table 9.12.1 Quantities of Major Work Items

Description	Unit	Quantity
Earthwork		
Clearing and grubbing	m2	3,200,000
Road embankment (General Fill)	m3	9,200,000
Road embankment (Sub Grade Fill)	m2	460,000
Pavement		
Surface (Asphaltic Concrete), 150mm (Main highway, Ramp)	m2	194,000
Surface (Asphaltic Concrete), 70mm (shoulder, Service Road)	m2	401,000
Surface (Concrete), 250mm	m2	5,200
Base course, 230mm	m2	100,000
Sub base course, 340mm	m2	137,000
Slope protection		
Rip-rap	m2	3,900
Gabion	m3	16,000
Sodding	m2	166,000
Plant Strip	m2	252,000
Road facilities		
Concrete curb	m	10,000
Guard rail	m	14,300
Wire fence	m	26,000
Line marking	m	120,000
Traffic sign	nos	100
Box culvert		
Type-A (H=5.7m, W=5.0m@2)	m3	900
Type-B (H=4.5, W=5.0m)	m3	500
Type-C (H=3.5, W=4.0m)	m3	200
Type-D (H=2.5, W=3.0m)	m3	7,200
Pipe culvert		
Type-1 (D=1.0m)	m	100
Building and others		
Operation related building	m2	6,000
Maintenance related building	m2	2,900

Appendix-10 Consideration of Railway Provision

10.1 GENERAL

This paragraph summarizes the necessary design standards and criteria to be adopted for the broad gauge railway, since the possibility of including the provision for broad gauge railway is to be considered as an alternative design of the Padma Bridge in this study.

These design standards and criteria are confirmed through discussions with officials of Bangladesh Railways.

Main important assumptions are described hereunder;

1) Broad Gauge (1,676mm) trains will be operated on the bridge,
2) Non-electrified single track will be installed, and
3) The Indian Railways standards and criteria are considered partly because there is a possibility of operation of freight wagons owned by Indian Railways in the future.

10.2 DESIGN CRITERIA TO BE ADOPTED

Railway design criteria applied to the Project are shown in the following.

Proposed speed on the bridge	50 km/hr
Maximum gradient	10 ‰ (on and around a bridge)
Minimum curve radius	340m (on and around a bridge)
Construction gauge	Shown in Figure 10.2.1
Track structure	Shown in Figure 10.2.2
Limit of train length & weight	528m and 19,570 kN

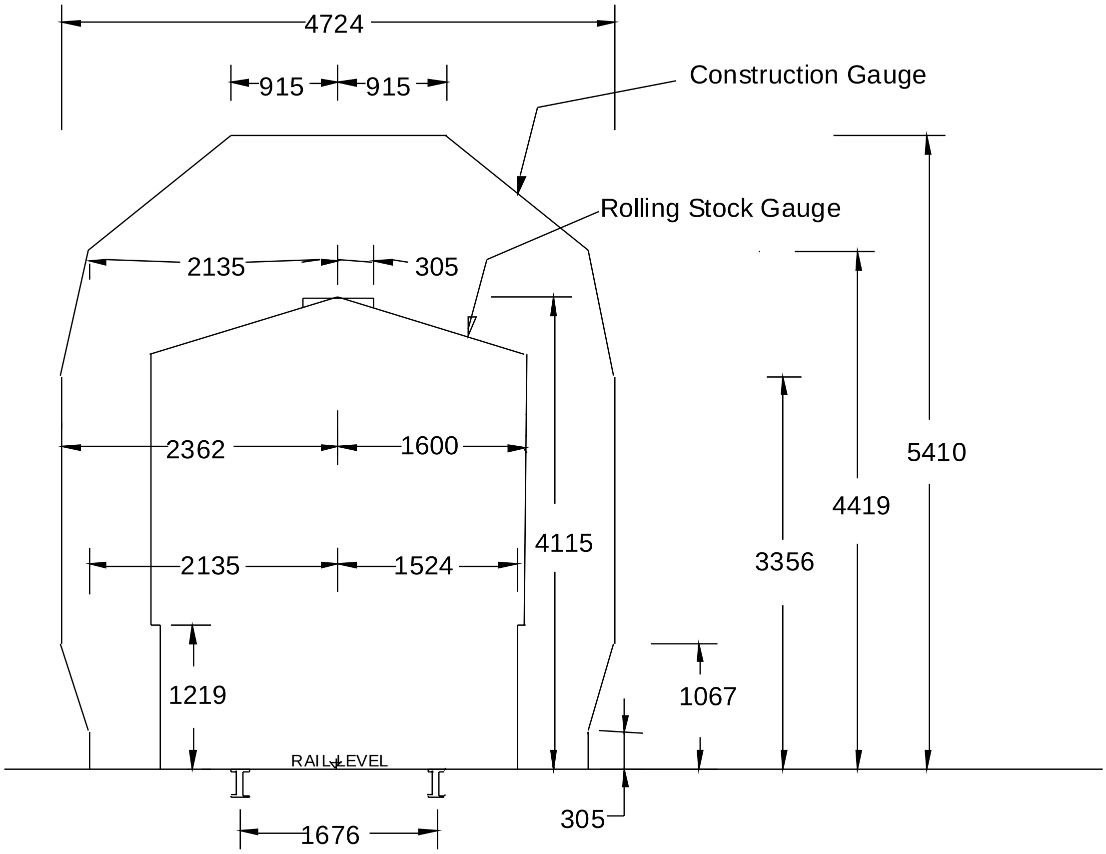


Figure 10.2.1 Construction Gauge (Unit: mm)

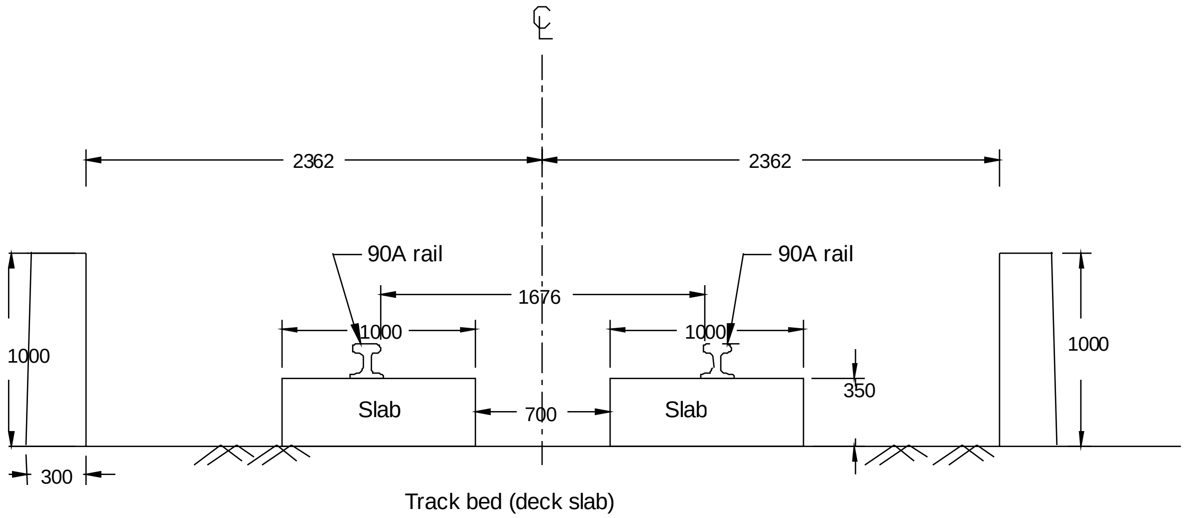


Figure 10.2.2 Typical Cross Section for Railway Portion (Unit: mm)

10.3 RAIL LOADS

In the Bangladesh Railway's standards, the followings are considered as railway related loads.

- Live Load
- Impact
- Centrifugal Load
- Longitudinal Load (Traction and Breaking)
- Wind Pressure Load

(1) Live Load

Proposed design load for railway is shown in Figure 3.1. Regarding the trailing load, the Indian Railways standard is applied due to considering trailers from/to India. Regarding the locomotive load, the Bangladesh Railway's standard is adopt because the Bangladesh Railway's locomotives will tow trailers of not only the Bangladesh Railway but also the Indian Railways.

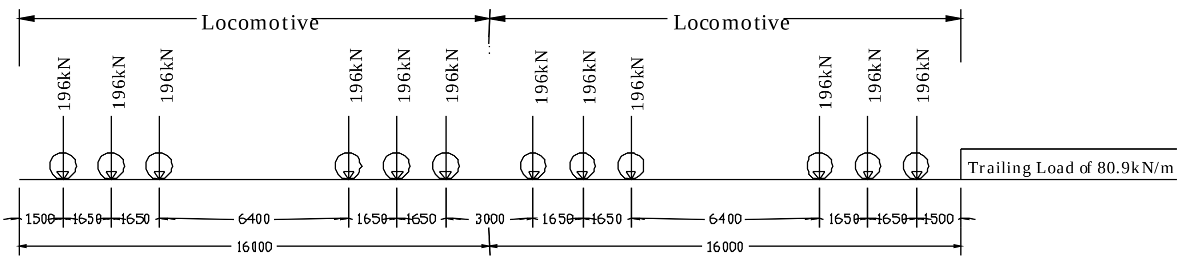


Figure 10.3.1 Proposed Design Load (Unit: mm)

(2) Impact

The impact load shall be taken as equal to the live load giving the maximum stress in the member under consideration multiplied by an impact coefficient ' I ' obtained from the following formula.

$$I = \frac{19.8}{13.7 + L}$$

(subject to a maximum of 1.00)
where L(m): Effective span length

(3) Centrifugal Load

The horizontal centrifugal force which may be assumed to act at a height of 1,830 mm above rail level is calculated by the following formula.

$$C = \frac{WV^2}{12.95R}$$

where C: horizontal effect in kN/m,
W: equivalent distributed live load in kN/m,
V: maximum speed in km/hr, and
R: radius of curve in meter

(4) Longitudinal Load

Although the Bangladesh Railway has a standard for longitudinal load, it is not able to be adopted because it does not deal with long-spanned bridges. On the other hand, the Japanese standard keeps up with all type of bridges. Therefore the Japanese standard , which is shown as following, is applied.

- Breaking Load: 25% of the design load
- Traction Load: 25% of the design locomotive load

(5) Wind Pressure Load

For loaded spans, the net exposed area is computed as the horizontal projected area of the moving train.

Maximum Train Height: 4.115m
Maximum Train Length: 528m

(6) Dead Load (track load only)

According to the typical cross section shown in Figure 10.2.2, the dead load for railway track per meter will be estimated as follows.

18.03 kN/m
(Slab: 24.5kN/m^3@0.7m^3=17.15kN/m, Rail(90A): 0.44kN/m@2=0.88kN/m)